DEPARTMENT OF THE ARMY TECHNICAL MANUAL **TM 3**

DEPARTMENT OF THE NAVY PUBLICATION **NAVSU**

OPERATOR, ORGANIZATIONAL
GENERAL SUPPORT, AND
MAINTENANCE MAN

LOADER, SCOO
D.E.D.

4-WHEEL DRIVE, PNEUM
HINGED FRAME STEER,
FRONT MOUNTED, HY
OPERATED, 10,500-LB C
(EATON, YALE & TOWN
MODEL 3000M) FSN 380

BEFORE OPERATION

Do not stand in front of wheel when inflating a tire, injury could occur by locking ring being blown from tire. wheels and set parking brake before performing tire maint

When filling fuel tank, provide metal-to-metal contact tank and filler nozzle to prevent static spark. Do not f to less than 4 inches from top.

Do not smoke or use open flame in the area when servic teries. Batteries generate a highly explosive gas.

Keep hands, floor, and controls free from grease, oil, to avoid possible injury.

DURING OPERATION

Do not allow anyone to stand between body segments whe is running.

Never leave operator's seat with lift forks raised fr

Never lift load over personnel on the ground.

Set parking break when leaving the seat.

Never carry personnel on forks unless a protected pal

Always travel with the forks raised high enough to cl ground conditions.

Never shift gears from forward to reverse without com stop.

Do not make sharp turns at high speed.

Do not operate truck in an enclosed area without prop

AFTER OPERATION

Never leave truck with forks raised.

NA

CHANGE
No. 2

DEPART
A
WASHINGT

Operator, Organizational, Direct, and General Support, and Depot

LOADER, SCOOP TYPE, D.E.D.; 4-WHEEL DRIVE, PNEUMATIC STEER, W/FORKLIFT, FRONT MOUNTED, HYDRAULIC OPERAT (EATON, YALE & TOWNE TROJAN MODEL 3000M) FSN 38

TM 5-3805-243-15, 1 October 1968, is changed as follows:

Page 6. Paragraph 2.1 is added as follows.

2.1. Maintenance ar

Refer to Table 1 for a and operating supplies of the loader.

Table 1. Maintenance and Operating Supplies

(1) Component application	(2) Federal stock number	(3) Description	(4) Quantity required f/initial operation	(5) Quantit require f/8 hrs operati
CRANKCASE	9150-265-9435	LUBRICATING OIL, Engine: MIL-L-2104, OE-30, 5 gal pail	19 qt	
FUEL TANK	9140-286-5283	FUEL OIL, Diesel, Fed Spec VV-F 800, Grade DF-2, bulk	83 gal	
GENERAL APPLICATION	9150-190-0905	GREASE, Automotive and artillery; MIL-G-10924, 5 lb can	AR	
RADIATOR	6850-243-1990	ANTIFREEZE, ethylene-Glycol 55 gal drum	AR	
BRAKE SYSTEM	9150-252-6375	BRAKE FLUID, Automotive, MIL-H-13910, 1 gal can	2 pt	
HYDRAULIC TANK	9150-265-9430	LUBRICATING OIL, engine: MIL-L-2104, OE-10, 55 gal drum	56 gal	
PLANETARY DRIVES	9150-577-5844	LUBRICATING OIL, Gear, MIL-L-2105, GO-90, 5 gal pail	59 qts	

PART 2

DIESEL ENGINE MODEL C-180

OPERATION AND MAINTENANCE

Change No. 3

Operator, Organizational, Direct
Support, and Depot Maintenan

LOADER, SCOOP TYPE, D.E.D., 4- PNEUMATIC TIRES, HINGED F W/FORKLIFT, FRONT MOUNTE OPERATED, 10,500 LB CAPAC YALE & TOWNE TROJAN M FSN 3805-074-637

TM 5-3805-243-15/NAVSUP 6004-A, 1 October 1968, is chang

Inside Front Cover. Add the following warning to the list of

WARNING

Operation of this equipment presents a noise hazard to pe
level exceeds the allowable limits for unprotected personne
which were fitted by a trained professional.

Page 6, Part 1. "FORMS AND RECORDS" paragraph is sup

REPORTING OF ERRORS

You can improve this manual by recommending improvemen
Changes to Publications and Blank Forms), or a letter, and ma
Support Command, ATTN: AMSTS-MPP, 4300 Goodfellow Blvd.
nished direct to you.

TB MED 251 contains information on noise and conservation

Page 2-1. Immediately after title, add the following warning

WARNING

Operation of this equipment presents a noise hazard to pe
level exceeds the allowable limits for unprotected personne
which were fitted by a trained professional.

fficial:

VERNE L. BOWERS
Major General, United States Army
The Adjutant General

Chief of Staff

W. R. DOWD, Jr.
Rear Admiral, SC, United States Navy
Commander, Naval Supply Systems Com

istribution:
To be distributed in accordance with DA Form 12-25B (qty rqr block No. 402), Organizational
enance requirements for Loaders.

TECHNICAL MANUAL
No. 5-3805-243-15
NAVY PUBLICATION
No. NAVSUP 6004-A

DEPAR

Washing

OPERATOR, ORGANIZATIONAL, DIRECT AND GE

MAINTENANCE MANUAL

LOADER, SCOOP TYPE, D.E.D., 4 WHEEL DRIVE,

FRAME STEER, W/FORKLIFT, FRONT MOUNTED, HYDR

CAPACITY (EATON, YALE & TOWNE, TROJAN MODEL

PART I. TROJAN TRACTOR SHOVEL - MODEL 3000

APPENDIX A
BASIC ISSUE ITEM LIST AND ITEMS TROOP INSTALLED OR AUTHORIZED
Section I. INTRODUCTION

A-1. Scope

This appendix lists basic issue items, items troop installed or authorized which accompany the loader and are required by the crew/operator for operation, installation, or operator's maintenance.

A-2. General

This basic issue items, items troop installed or authorized list is divided into the following sections:

a. Basic Issue Items List—Section II. Not applicable.

b. Items Troop Installed or Authorized List Section III. A list in alphabetical sequence of items which at the discretion of the unit commander may accompany the end item, but are NOT subject to be turned in with the end item.

A-3. Explanation of Columns

The following provides an explanation of columns in the tabular list of Basic Issue Items List, Section II, and Items Troop Installed
III.

a. Source, Maintenance, a
(SMR): Not applicable.

b. Federal Stock Number.
the Federal stock number a
will be used for requisitionin

c. Description. This colun
item name and any additi
item required.

d. Unit of Measure (U/M
betic abbreviation indicating
of the item upon which th
e.g., ft, ea, pr, etc.

e. Quantity Authorized (I
Authorized Only). This colun
of the item authorized to be

Section III. ITEMS TROOP INSTALLED OR AUTHORIZE

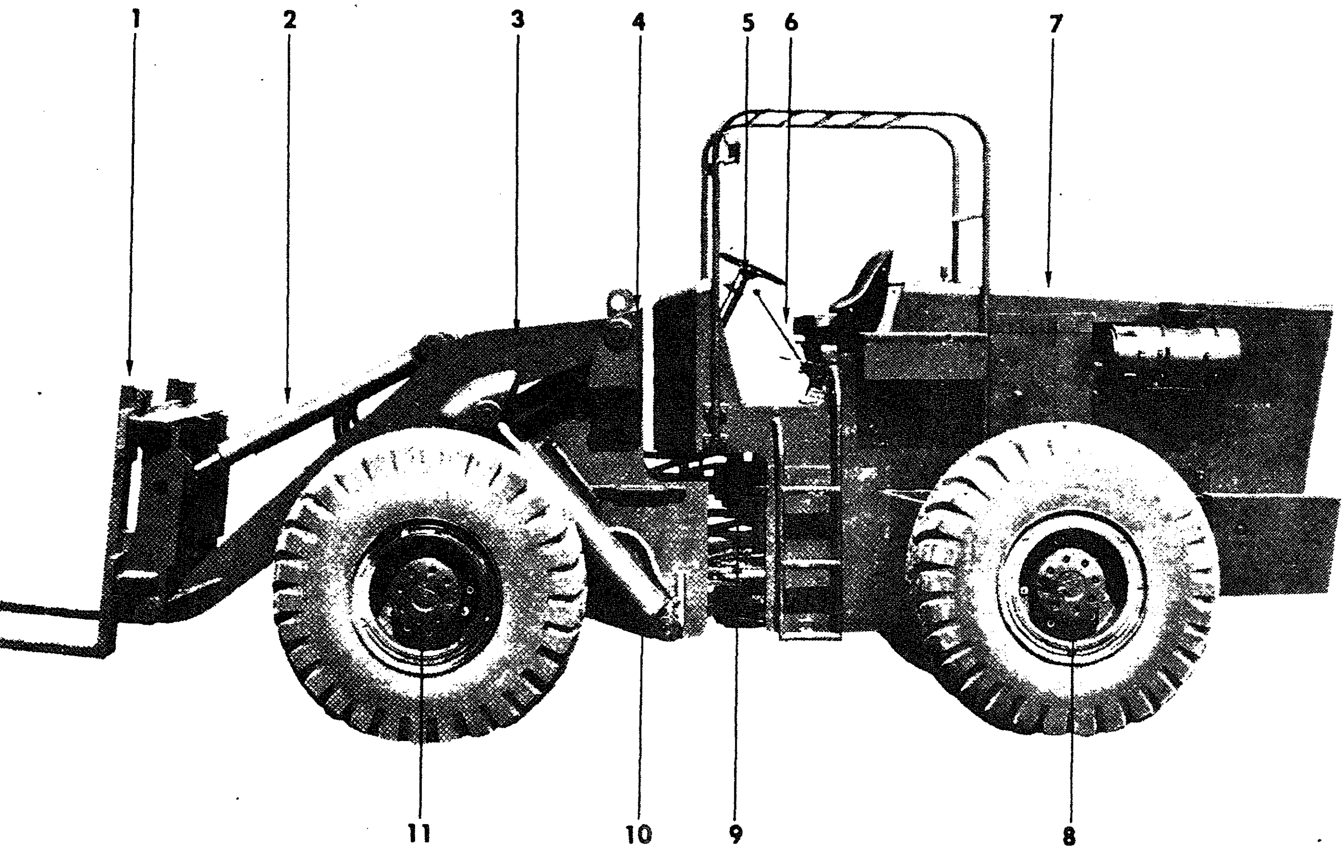
(1) SMR code	(2) Federal stock number	(3) Description Ref No. & Mfr code	Us on
	4210-889-2221	EXTINGUISHER, FIRE	

By Order of the Secretaries of the Army and the Navy:

CREIGHTON W. A
General, United Stat
Chief of Staff

Official:
VERNE L. BOWERS

DIRECT SUPPORT, GENERAL SUPPORT AND DEPOT MAINTENANCE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TROJAN TRACTOR SHOVEL — MODEL 3000

FORMS AND RECORDS

Report of errors, omissions, and recommendations for improving this publication by the individual user is encouraged. Reports should be submitted on DA Form 2028 (Recommended Changes to DA Publications) and forwarded direct to the Commanding General, U.S. Army Mobility Equipment Command, ATTN: AMSME-MPP, 4300 Goodfellow Boulevard, St. Louis, Missouri 63120

DA forms and procedures used for equipment maintenance will be only those prescribed by TM 38-750, Army Equipment Record Procedures.

SERIAL NUMBER PLATES

The serial number plate is located in the operator's compartment to the left of the seat and below the parking brake lever. See Fig. 2.

The Engine serial number plate is located on the engine to the rear of the injection pump and air compressor. The engine model and serial number are given on the engine serial number plate.

The transmission serial number plate is located on the right rear of the transmission case. The part number and serial number of the transmission are stamped on the plate. See Fig. 1.

PREPARATION FOR OP

Before starting your TRO
it on level ground and mal

1 Check the entire machi
   A. See that all bolts, n
   are tight.
   B. Pay particular attenti
   engine mounting bol
   Refer to the torque
   manual.

2 Check all of the drai
opening plugs, fuel li
cleaner connections to s
not leak.

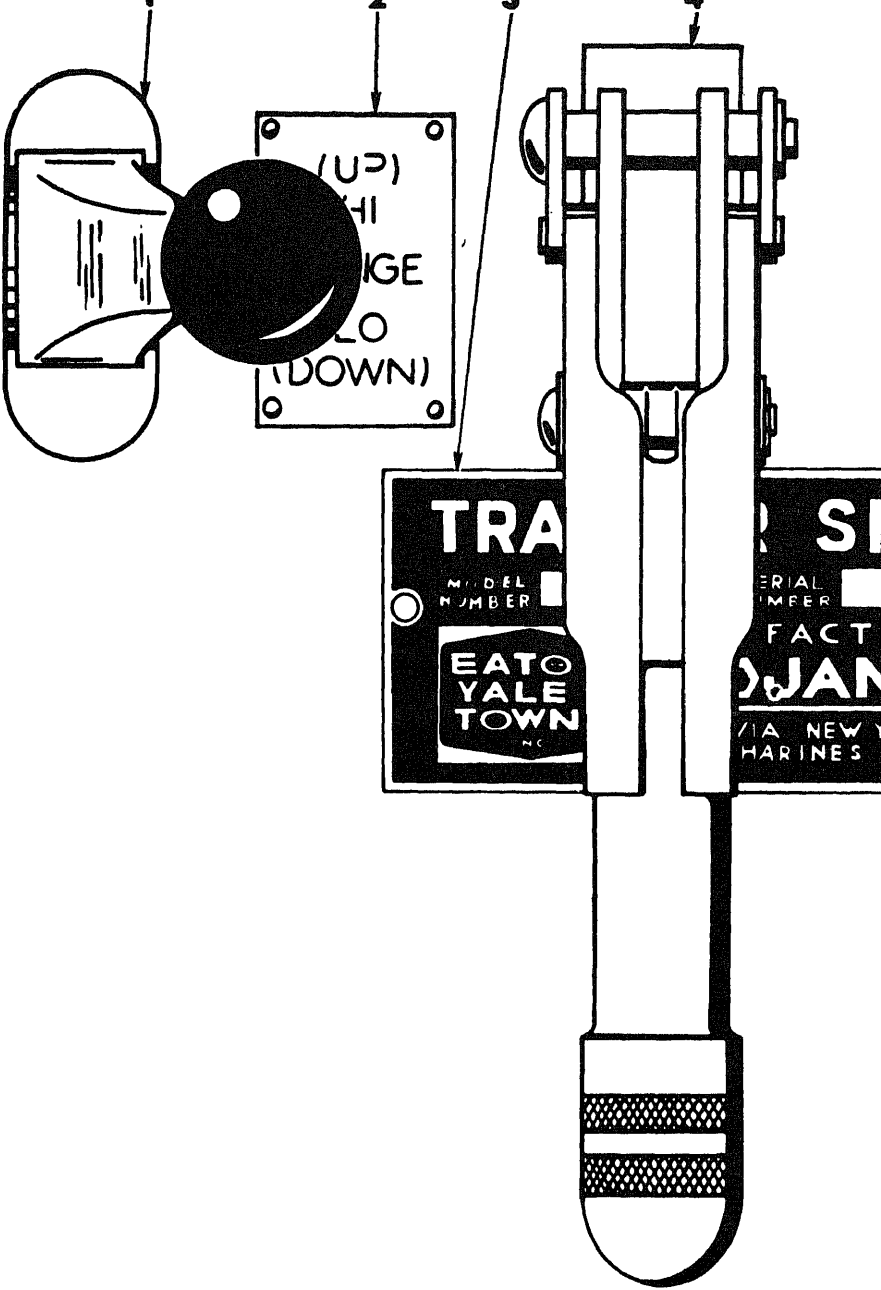
3 Fill the fuel tank.

4 Check each battery cel
covered with fluid. Ac
cover plates if necessar

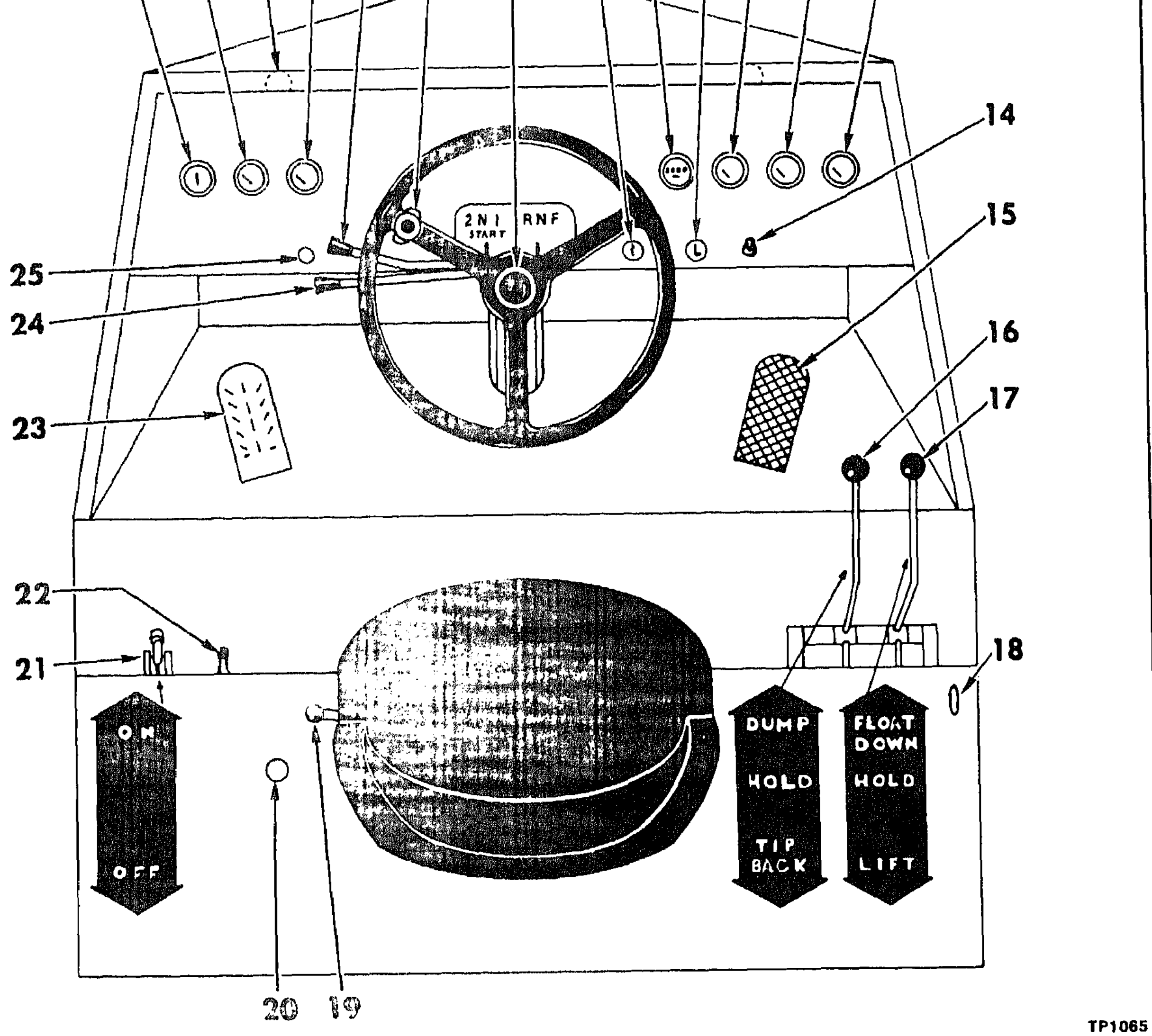
5 Check to see that the co
for anti-freeze protectio
expected.

6 Grease all lubrication p
cation section of this m
of lubrication required

7 Check the oil level of t
to the lubrication secti
tion, quantity and type
   A. Engine crankcase
   B. Front drive axle (c
   differential)
   C. Rear drive axle (o
   differential)
   D. Main hydraulic rese
   E. Transmission



1. Hi-Lo Range Switch
3. Serial



1. Ammeter
2. Engine Oil Pressure Gauge
3. Dash Lamp
4. Engine Water Temperature Gauge
5. Speed Range Control Lever
6. Steering Wheel Spinner
7. Horn Button
8. Ignition Switch
9. Engine Hourmeter
10. Light Switch
11. Air Pressure Gauge
12. Transmission Clutch Pressure Gauge
13. Torque Converter Temperature Gauge
14. Overhead Light Switch
15. Accelertor Pedal
16. Fork Control Lever
17. Lift Arm Control Lever
18. Water Fording Cable
19. Seat Adjustment Control
20. Ether Starting Kit
21. Parking Brake Lever
22. Hi-Lo Range Switch
23. Brake Pedal
24. Directional Control Lever
25. Starter Button

Fig. 3. Operator's Compartment

left position on the instrument panel.

2. Purpose: The ammeter indicates the amount of current flow to and from the batteries. A reading in the minus − range indicates that the batteries are discharging; a reading in the plus + range indicates that the batteries are charging.

ENGINE OIL PRESSURE GAUGE (2 Fig. 3)

1. Location: The engine oil pressure gauge is the second gauge to the left of center on the panel.
2. Purpose: The engine oil pressure gauge indicates the pressure in the engine lubricating system. Normal operating pressures are 10/30 psi(idle); 40/75 psi at rated speed.

DASH LAMPS (3 Fig. 3)

1. Location: Two dash lamps are mounted above the instrument panel, one for each side of the panel.
2. Purpose: The dash lamps illuminate the instrument panel during night operation; they are controlled by the main light switch.

ENGINE WATER TEMPERATURE GAUGE (4 Fig. 3)

1. Location: The engine water temperature gauge is the first gauge just to the left of center on the panel.
2. Purpose: The engine water temperature gauge indicates the temperature of the engine coolant. Operating temperature 165° to 195°F.

SPEED RANGE CONTROL LEVER (5 Fig. 3)

1. Location: The speed control lever is located left and forward of the steering wheel, and is the lower of the two levers.
2. Purpose: The speed control lever, *in conjunction with* the transmission range lever, controls the speed at which the machine moves. Move the lever forward so the indicator is at 1 for first speed. Pull the lever straight back so the indicator is at 2 for second speed. The center position, with this indicator at N-Start, puts the transmission in neutral, the position required for starting. Safety switch (6 Fig TP1074) is closed only when switch is in "N" position.

STEERING WHEEL SPINNER (6 Fig. 3)

1. Location: The steering wheel spinner is located on the steering wheel.
2. Purpose: The *steering wheel spinner* allows the operator to turn the wheel rapidly and easily in either direction.

HORN BUTTON (7 Fig. 3)

1. Location: The horn button is mounted in the center of the steering wheel.
2. Purpose: The horn button operates the electric horn. Depress the button to sound the horn.

edge of the instrument panel, to the right of the center of the panel.

2. Purpose: The ignition switch energizes the starting motor circuit and all gauges and switches includ engine hourmeter. Turn the key to the right for the ON position. Turn the key to the OFF position before leaving the operator's seat. Refer to shut-down procedure.

ENGINE HOURMETER (9 Fig 3)

1. Location: The engine hourmeter is mounted just to the right of the center of the panel.
2. Purpose: The engine hourmeter indicates the operating time of the machine. It registers the operating *time in hours and tenths of an hour.* The operating time, as indicated on the hourmeter, should be used as a basis for lubrication and maintenance schedules.

LIGHT SWITCH (10 Fig. 3)

1. Location: The light switch is located to the right of the steering wheel below the hourmeter gauge on the instrument panel.
2. Purpose: Pull the light switch out to the first position to turn on the dash lights, headlights and red tail lights. Pull it out to the second position to turn out the red taillights and to turn on accessory equipment connected to tail light terminal block. Dash lights and headlights *remain on.*

AIR PRESSURE GAUGE (11 Fig. 3)

1. Location: The air pressure gauge is mounted next to the hourmeter, just to the right of the steering wheel.
2. Purpose: This gauge indicates the air pressure in the air reservoir available for service brake power cluster operation. The gauge should read between 90 and 120 P.S.I. The machine must not be moved unless there is at least 60 pounds air pressure in the reservoir. *If the air pressure falls below the specified* range while operating, shut down immediately; refer to the brake section of this manual and correct the cause.

TRANSMISSION CLUTCH PRESSURE GAUGE (12 Fig. 3)

1. Location: The transmission clutch gauge is the third gauge to the operator's right on the panel.
2. Purpose: This gauge indicates the pressure of the transmission hydraulic system at the control valve *that is available to actuate the transmission clutches.* This pressure should read between 240 and 280 P.S.I. If clutch pressure falls below 240 P.S.I., investigate the cause immediately to prevent transmission clutch slippage. Refer to the transmission section in this manual.

panel.

2. Purpose: This gauge indicates the temperature of the oil in the torque converter and transmission lubricating system as it leaves the torque converter. It will normally register between 210° and 230°F. If the *temperature rises above 230°F., shift to a lower op*erating range. Should the temperature remain above normal, investigate immediately and correct the cause. Refer to the torque converter section in this manual.

OVERHEAD LIGHT SWITCH (14 Fig. 3)

1. Location: The overhead light switch is located on the right side of the instrument panel below the air pressure gauge.
2. Purpose: Push the toggle up to turn the overhead lights on, push the toggle down to turn the overhead lights off.

ACCELERATOR PEDAL (15 Fig. 3)

1. Location: The accelerator pedal is mounted on the front floorboard, to the right of the operator.
2. Purpose: Press the accelerator pedal to increase the speed of the machine. Release pressure to decrease speed.

FORK CONTROL LEVER (16 Fig. 3)

1. Location: The fork control lever is the inside lever located to the operator's right.
2. Purpose: The fork control lever has three positions for fork control. Push the lever in the forward dump position to tilt the fork to dump the contents; release the lever to the center hold position to hold the fork in any given position; place the lever in the rear tip back position to hold the fork in an upright position for transporting loads. The lever operates at any fork height.

LIFT ARM CONTROL LEVER (17 Fig. 3)

1. Location: The lift arm control lever is the outer lever located to the right of the operator.
2. Purpose: The lift arm control lever has four positions. To raise the fork, pull the lever back to the lift position. To hold the fork at any height, move the lever forward one position to HOLD. To lower the fork slowly with positive hydraulic down pressures, move the lever forward one position to the DOWN position. Move the lever all the way forward to the FLOAT position to lower the fork quickly, or to allow the fork to move freely

WATER-FORDING CONTROL (18 Fig. 3)

1. Location: The water-fording control is mounted to the right of the operator and behind the valve control levers.

CAUTION: Do not operate machine in water with control in down position. Engine breather system will take in water.

SEE PAGE 13 FOR ADDITIONAL INSTRUCTIONS

SEAT ADJUSTMENT CONTROL (19 Fig. 3)

1. Location: The seat adjustment control is located on the seat base, to the left of the operator.
2. Purpose: Pull the seat adjustment control to the rear to release the catch; this permits the operator to move the seat backward or forward.

ETHER START KIT CONTROL (20 Fig. 3)

1. Location: The ether start kit control is to the left of the operator's seat above the parking brake lever.
2. Purpose: The ether start kit supplies a charge of ether to the intake manifold for starting in cold weather. To use kit, pull the control once, then immediately press the starter button. Refer to start-up procedure in cold weather (+40° F. and below)

ENGINE SHUT-DOWN CONTROL (8 Fig. 3)

Turn ignition switch to OFF position.

PARKING BRAKE LEVER (21 Fig. 3)

1. Location: The parking brake lever is located immediately to the left of the operator's seat.
2. Purpose: Pull the lever up to set the parking brake. Release the parking brake by moving the lever down before putting the machine in motion to prevent damage to drum and lining.

TRANSMISSION RANGE LEVER

(22 Fig. 3) (1 Fig. 2)

1. Location: The transmission range lever is the second lever to the left of the operator's seat.
2. Purpose: The transmission range lever selects either high or low transmission range. The high range provides the higher speeds for either setting of the speed control lever. The low range provides the lower speeds for either setting of the speed control lever. Move the lever UP for high speed range. Move the lever DOWN for the low speed range. By operating this lever in conjunction with the speed control lever, four shift speeds are available from the transmission.

STOP MACHINE WHEN SHIFTING FROM HIGH TO LOW RANGE OR VICE VERSA.

When shifting from high range to low range, the following steps must be taken:

1. Stop the machine.
2. Move directional lever and speed range lever into neutral position.
3. Move high range lever down for low speed range and up for high speed range. If the range lever will not travel from high range to low range or vice-versa, engage the directional lever and the range lever and inch the machine either forward or reverse. Disengage the two levers and attempt the Hi-Lo shift again. This procedure is recommended to line up the shift coupling in the transmission rather than to grind the gears thus resulting in improper wear.

IMPORTANT: The transmission range lever (22) Fig. 3) must NOT be moved UP to DOWN while the machine is in motion. Stop machine before the lever is moved from one position to another.

SERVICE BRAKE PEDAL (23 Fig. 3)

1. Location: The service brake pedal is located on the floor in the front of and to the left of the operator.
2. Purpose: Press forward on the service brake pedal to actuate the brake power clusters, applying brakes to all four wheels.

CAPACITIES

	Approx.
Cooling System:	
Cummins C-180-CI	48 U. S. Qts.
Fuel Tank	83 U. S. Gals.
Hydraulic System, Main and Steering	50 U. S. Gals.
Transmission Hydraulic System	24 U. S. Qts.
Front Axle:	
Differential	6 U. S. Gals.
Hubs	6 U. S. Qts.
Rear Axle:	
Differential	6 U. S. Gals.
Hubs	5 U. S. Qts.
Crankcase	4 U.S.Gals.

machine is moved.

DIRECTIONAL CONTROL LEVER (24 Fig. 3)

1. Location: The directional control lever is locat left and forward of the steering wheel and is t uppermost of the two levers.
2. Purpose: The directional control lever controls t forward or reverse movement of the machine. Mo the lever forward so the pointer indicates F to p the transmission in forward range; move it to t rear so the pointer indicates R to put the transmissi in reverse. The center position, with the indicator N, puts the transmission in neutral.

STARTER BUTTON (25 Fig. 3)

1. Location: The starter button is located to the left the steering wheel below the engine temperatu gauge.
2. Purpose: The starter button closes the circuit to t engine starter solenoid. Press to operate engi starter; Release when engine starts. To avoid ove heating the starter, do not crank for more than seconds in any one cranking period. Refer to start-u procedure.

FUEL GAUGE

1. Location: The fuel gauge is mounted in top of t fuel supply tank to the right of the operator.
2. Purpose: The fuel gauges indicates the amount fuel in the tank at all times.

DO NOT FILL TANK TO LESS THAN 4 INCHES FROM TOP.

ELECTRICAL SYSTEM

System Voltage	24 Vol
Ground	Negati
Head Lamps	24 Vol
Tail Lamps	24 Vol
Work Lights	24 Vol
Main Circuit Breaker	70 Am
Auxiliary Circuit Breaker	
Poles	
Ratings	3 @ 15 Amp.; 1 @ 30 Am
Battery	
Voltage	12 Vol
(2 Batteries in Series)	
Amp. Hour Cap.	1

PRESSURES

Main Hydraulic			1650 P.S.I.	
Fork Circuit Relief Valve			1100 P.S.I.	
Lift Cylinder Relief Valve			1900 P.S.I.	
Steering Hydraulic			1300 P.S.I.	
Transmission Clutch			240 to 280 P.S.I.	
Air Brake			90 P.S.I. Min.; 120 P.S.I. Max.	
Tires		Pressure:		
(23.5 x 25) 24 Ply SGL		Min.	Max.	Rough Terrain
SGL—Sure Grip Lug	Front	45	50	35
	Rear	25	30	25

Note: While operating at reduced tire pressure, speed must be limited to 12 mph.

carefully read the engine starting instructions

Attempting to start or run the engine before studying these instructions may result in permanent engine damage.

With the engine fully serviced in accordance with the applicable engine operator's manual and with the operator thoroughly familiar with the locations and functions of the Operating Controls, Instruments, and Switches, the forklift truck is started according to the following instructions:

WARM WEATHER

1. Place speed range control lever in neutral (N-Start) position.
2. Turn ignition key to ON position.
3. Depress accelerator pedal to full fuel position.
4. PRESS starter button firmly to start engine. Do not crank for more than 30 seconds in any one cranking period to avoid overheating the starting motor.

CAUTION: If the engine fails to start, DO NOT press the starter button again until the starting motor has stopped rotating. Engaging the starting motor while rotating may result in serious damage to the engine or starting motor.

5. Immediately after starting, observe the engine oil pressure gauge. If no pressure is shown within 10 to 15 seconds, stop the engine and check the engine lubricating system.
6. Run the engine at part throttle for 5 minutes for proper warm up.
7. Allow engine oil pressure, transmission clutch pressure, and brake air pressure to stabilize before moving machine.

COLD WEATHER (+50°F. and Below)

1. Place speed range control lever in neutral (N-Start) position.
2. Turn ignition key to ON position.
3. Set accelerator pedal to full fuel position.
4. Pull the ether start kit control, release and immediately press the starter button to start the engine. Crank in 30-second intervals until engine starts. Allow 1- to 2-minute intervals between cranking periods to prevent overheating the starting motor.

NOTE: The ether start kit control is connected to an ether start kit mounted on a plate on the back of the main hydraulic tank in the engine compartment. The starting fluid used in this kit is contained in a disposable cylinder.

This is the safest and most modern way to handle this highly volatile fluid.

The following steps will assure good starting in cold weather:

1. Keep the engine in good operating condition. The highest possible compression pressures and temperatures demand good valve and piston ring seating. Clean injector tips insure proper fuel atomizing and even combustion.
2. Low temperatures reduce battery output. Fully charged batteries deliver the greatest possible cranking power.
3. Use clean diesel fuel, No. 1 or No. 2, and drain condensed moisture from the bottom of the fuel tank periodically to prevent fuel line freeze-ups. Tighten all fuel connections to prevent air locks.
4. Be cautious when using ether start kit. An excess of starting fluid can cause extremely high cylinder pressures and could result in serious engine damage not covered by the warranty.
5. Make use of any available shelter for the machine, as any shelter will improve starting conditions to some degree.
6. Use the correct grade of engine oil recommended by the engine manufacturer for the temperature conditions expected. Thinner oils take less cranking power in severe cold.

WARM UP PERIOD

After the engine has started and is running smoothly, alllow it to warm up to its most efficient operating temperature by operating through a complete work cycle at a moderate pace. While the engine is warming, check the following:

1. Engine oil pressure.
2. Ammeter will show a high charge immediately after cranking, then gradually show decreasing charge as the batteries become more fully charged. A continuous high charge rate is an indication of an electrical malfunction. Determine the cause of the trouble and make necessary corrections.
3. Disengage parking brake and work at moderate pace until required temperature and pressures are stabilized.
4. Transmission clutch pressure should be 240 P.S.I. minimum in all speeds forward and reverse.
5. When all systems have reached operating pressures and temperatures (approximately 30 minutes), stop the machine and visually check for external engine oil leaks, engine coolant leaks, fuel line leaks, transmission oil leaks, hydraulic oil leaks, and axle lubricant leaks.

When the engine has fully warmed up, all operating pressures and temperatures are within requirements, and above checks are made, the machine is ready for full operation.

SHUT-DOWN PROCEDURE

When stopping the engine, speed must be reduced to idle for 5 minutes to allow the coolant and lubricating oil to carry accumulated heat away from bearings, combustion chambers and other moving parts.

ENGINE

Turn the ignition switch to the OFF position. This actuates a solenoid fuel shut-off valve on the fuel pump, stopping the flow of fuel to the engine.

TOWING

If for any reason the machine has to be moved from one location to another, it must be moved under its own power. If towing is necessary, the drive train must be disconnected to avoid damage to the clutch pack.

FORDING AND WATER OPERATION

(1) Before fording or water operation, close engine fording valve (18, Fig 3) by pulling UP on knob. CHECK ENGINE OIL LEVEL EVERY TWO (2) HOURS WHEN OPERATING WITH VALVE CLOSED.

(2) IMMEDIATELY AFTER fording or water operation, check all differential, final drives, engine and hydraulic systems for water contamination. Drain and refill before resuming operation if water is in system.

(3) After SALT WATER OPERATION, additional maintenance must be performed. Wash or hose down entire machine with fresh water, remove all wheeld and clean brake system, especially wheel cylinder pistons, to remove salt water contamination.

Place the speed range control lever in the first (1) gear position and the directional control lever in the forward (F) position. Place the transmission range lever (5, Fig. 3) in the low position. Lower the fork with the lift arm control lever. Use the fork control lever to position the fork tines parallel to the ground. Drive the machine slowly forward to push the fork tines underneath the load. Raise the fork with the lift arm control lever until the load is approximately 14 inches above the ground. Pull the fork control lever back a little to tip the fork and load back. Push the lift arm control lever to the "hold" position. Keep the load low and fork slightly tipped back and carry the load to the loading area.

TRANSPORTING THE LOAD

When transporting the load, travel speed of the machine will depend on the length of the haul and type of surface over which the machine must travel. Rough terrain and sharp turns require fairly slow speeds. Carry a loaded fork approximately 14 inches above the ground. Never transport a load with the fork raised more than half way. Hold the fork as near to the ground as conditions permit to improve stability of the machine, especially on slopes or when turning.

UNLOADING THE FORK

Raise the fork with the lift control lever until it clears the top edge of the truck side or unloading area. Keep the machine perpendicular to the truck side or unloading area, so the load can be unloaded evenly inside the unloading area. When the fork has reached the proper height, place the lift arm control lever in the "hold" position and push the fork control lever forward to the "dump" position slowly and gradually. Do not suddenly push the fork control lever all the way forward — the load may unload too quickly and damage the truck body. After the fork has emptied, pull the fork control lever to the "tip back" position and back the machine away from the truck or unloading area. Place the lift control lever in the "float" position to lower the fork. Proceed back to the loading area to get another load.

TRAVELING WITHOUT A LOAD ON THE FORK

When moving the machine to another job, the empty fork should be approximately 14 inches off the ground. Drive in a high speed range to the new job site. Do not drive the machine in reverse to attain higher speed or more steering control. The operator has relatively poor visibility over the rear hood of the machine and fast, continuous rear travel may cause the engine from traveling backward neutralizes the air flow from the pusher fan. Engine overheating may result.

SAFETY LINKS

LOCATION: The safety links are mounted and carried on each side of the front frame section. (See Fig. 4)
Purpose: The safety links when installed (See Fig. 5) provide a means of locking both frame sections stationary to permit work to be performed between the frame sections without causing injury to personnel. The safety links must also be installed when the unit is to be transported by truck from one job site to another.
Store safety links as far forward on block as possible to prevent contact with rear section of truck when in turned position.

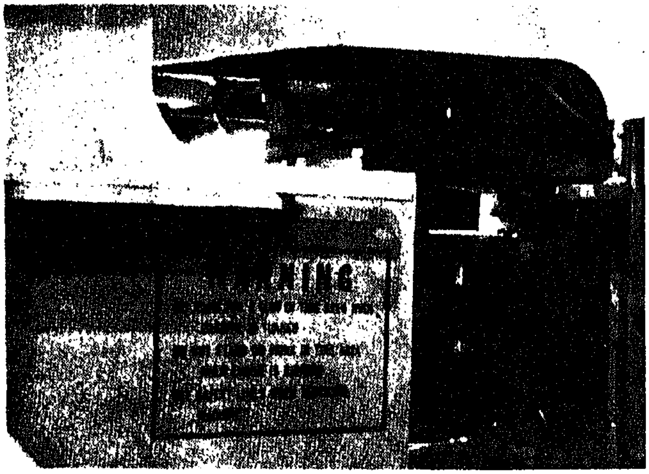


Fig. 4. Safety Links — Carried Position

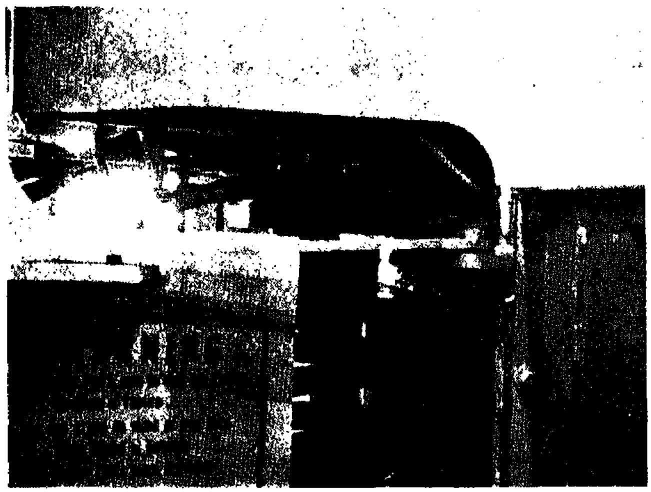


Fig. 5. Safety Links — Locked Position

Operator must take certain responsibilities for daily duties of lubrication and adjustment to keep the machine operating at its peak proficiency.

Quick attention to certain indications of trouble or the proper adjustment can save expensive down time and serious machine failures.

AIR BRAKE SYSTEM

See Brake System.

BATTERIES

The batteries are located on the left side of the machine to the right of the ladder used to enter the operator's compartment. Inspect the batteries daily. Keep terminals and cables clean and tight, and be sure that distilled water is above the plates and separators in each cell. (See Fig. 6).

FORK CYLINDER HEAD ADJUSTMENT

It is extremely important that the fork cylinder rods have exactly the same stroke. The rods are adjusted by loosening the socket bolts (Fig. 7) on the head (4) and rotating the rod by placing a wrench on the rod flat (2). When adjustment is completed, tighten the bolts (3) to 250 lbs. ft. torque.

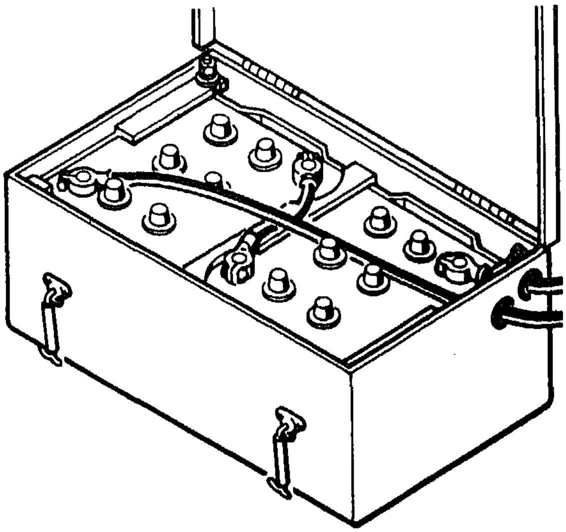


Fig. 6. Battery Installation

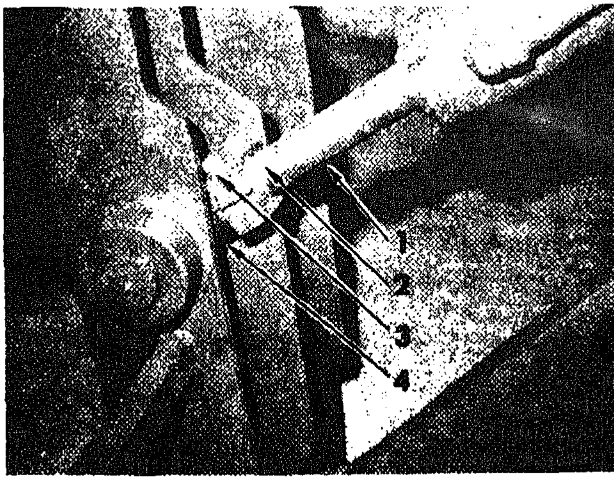


Fig. 7. Fork Cylinder Head

1. Piston Rod
2. Rod Flat
3. Capscrews
4. Head

ENGINE AND ACCESSORIES

For all adjustments on the engine and accessories. consult Engine Operation and Maintenance.

LIGHTS

The head lamps and rear work lamps are easily removed from the outside of the machine for replacement. Press rubber cover from inside to outside. Lift out lamp and replace. The tail and stop lamps are included in a single, double-filament bulb. For bulb replacement press rubber cover from inside out. Remove bulb and replace.

MAIN HYDRAULIC SYSTEM

For all hydraulic system adjustments, refer to the hydraulic system section.

PARKING BRAKE

When slack develops in the parking brake linkage, perform the following adjustments:

. With the lever in the "RELEASE" position, turn the acorn cap on the end of the handle clockwise. Test for good pull; the handle is pulled up over center to the applied position. See Fig. 8.

. If adequate adjustment cannot be obtained at the parking brake lever, put brake lever in released position and back off acorn cap. Adjust the clevis of the parking brake rod at the parking brake arm at the front of the transmission. (See clevis adjustment) adjust the brake lever as described in step 1. See Fig. 9.

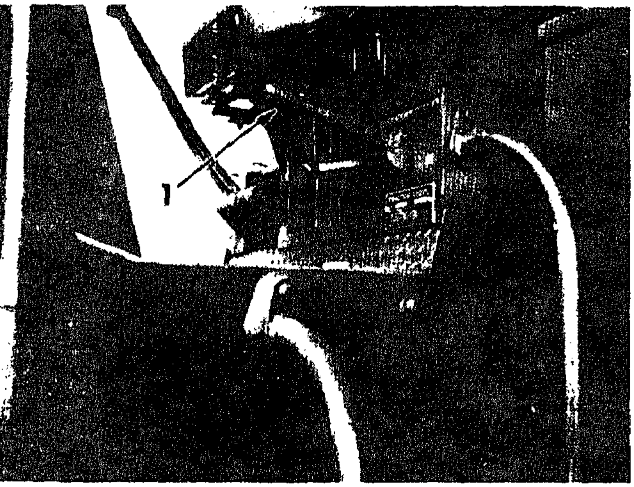


Fig. 8. Parking Brake Lever

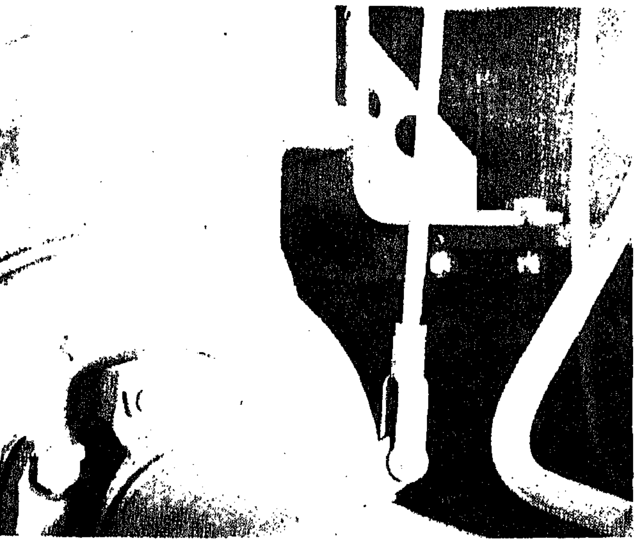


Fig. 9. Parking Brake Clevis

ROPELLER SHAFTS

Vhen installing propeller shafts, make sure the keyays are properly engaged in the mating yokes; install pecial heat-treated bolts, and torque, to 95 lbs. ft.

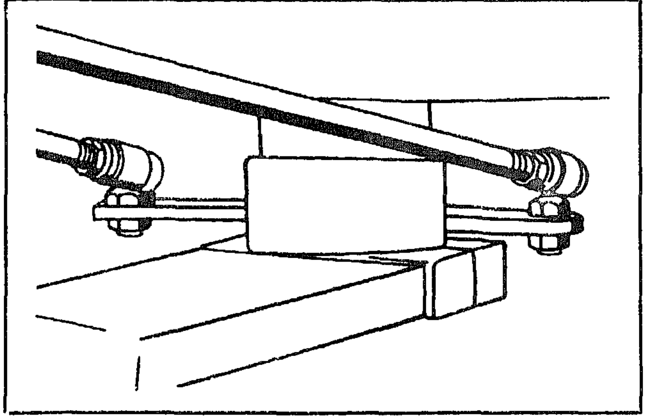


Fig. 10. Ball Joint Adjustment

SHIFT LEVERS

It is very important that the shift levers on the steering column are properly aligned so the position pointer indicates the correct position of the control lever. The direction control lever pointer should always point to neutral (N) when the transmission is in neutral for safety reasons. The speed control lever must register so the lever arm position in the quadrant places the transmission control valve plunger in a detent position to prevent clutch slippage. Position of the shift levers can be adjusted at the ball joints, just below the floorboards, and at the clevis at the transmission control valve connection. See Fig. 10 and 11.

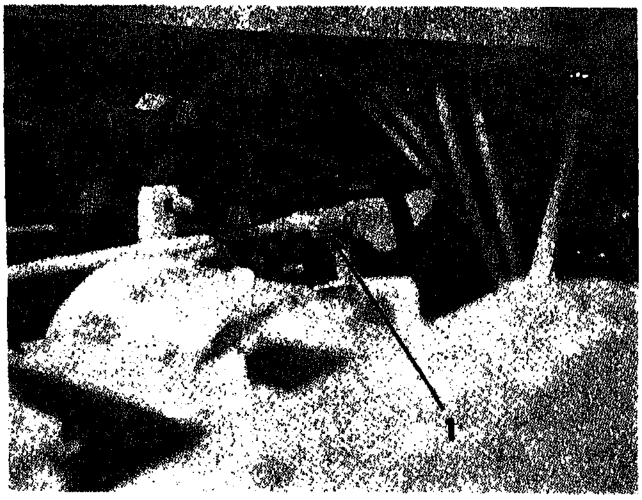
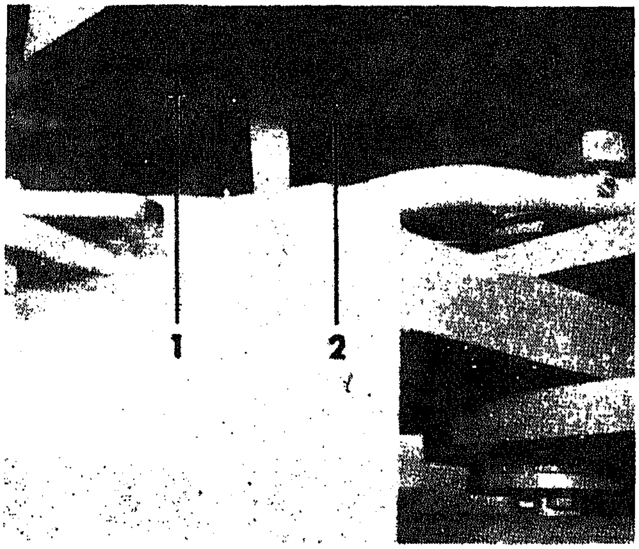


Fig. 11. Clevis Adjustment

For adjustments of the steering hydraulic system, refer to the steering hydraulic system section.



1. Jam Nut 2. Set Screw

Fig. 12. Steering Stop Adjustment

STEERING STOP ADJUSTMENT

Position machine on flat surface. Rotate steering wheel until front section is parallel with rear section of machine. Align front section and rear sections using a straight edge.

Pitman arm should now be in a vertical position.

Loosen jam nuts (1). Slowly turn steering wheel sharp to the right until front section stops on stop block on rear frame section. CAUTION: DO NOT FORCE STEERING WHEEL BEYOND THIS POINT. Screw front setscrew in or out until pitman arm stops on head of set screw. Tighten jam nut securely.

Slowly turn steering wheel sharp to the left until front section stops on stop block on rear frame section.

CAUTION: DO NOT FORCE STEERING WHEEL BEYOND THIS POINT. Screw rear setscrew in or out until pitman arm stops on head of setscrew. Tighten jam nut securely.

With setscrews properly adjusted and jam nuts secure, re-check setting by turning front frame section both left and right noting position of pitman setscrew. See Fig. 12.

CAUTION: Overturning and allowing the front section to strike stop blocks hard will result in stop block damage.

Periodically check steering stop blocks to insure co rectness of size. Use an accurate scale and measu distance from frame to top of both blocks. Corre measurement should be one inch from frame to top block. Replace if necessary. Readjust setscrews wh stop blocks are replaced or pitman arm is replaced.

TRANSMISSION TORQUE CONVERTER

Refer to the transmission or torque converter secti for all adjustments, trouble shooting and maintenan

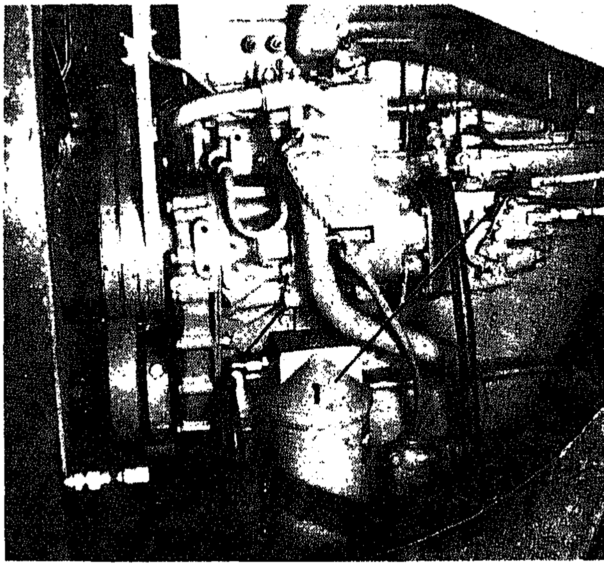


Fig. 13. Accelerator Rod

VARIOUS CLEVIS AND BALL JOINT ADJUSTMENTS

Various clevis and ball joint adjustments can be ma to position levers and pedals for most convenient c eration. These adjustments are made as follows:

1. Loosen the jam nut.
2. Remove cotter pin and clevis pin on clevises. Remo the mounting nut on ball joint.
3. Turn clevis or ball joint to lengthen or shorten ro
4. Lock the clevis or ball joint with the jam nut prevent loosening.
5. Reinstall the clevis pin and cotter pin on clevis Secure ball joints with the mounting nut.

wheel nuts can cause broken wheel studs, and affect steering and load distribution. Tighten to 500 lbs. ft. torque, dry thread. This is equal to 150 pounds of force exerted at the end of a 3½-foot bar or 200 pounds of force exerted at the end of a 2½-foot bar. (Fig. 14).

A BROKEN STUD IS A DIRECT RESULT OF OPERATION WITH LOOSE WHEEL NUTS. WHEN A BROKEN STUD IS REPLACED, THE STUD ON EACH SIDE OF IT MUST BE REPLACED ALSO.

Because wheel cap nuts tend to loosen when a machine is being transported, the following is recommended upon receipt of delivery.

obstructions such as clotted paint, burrs, dirt, etc. that could prevent good wheel-to-hub contact.

Check the threads of the studs at the hub face for evidence of damage, cross-threading, or dirt.

Remount wheel and tighten ball faces of wheel nuts into countersunk seats in wheel. Then tighten nuts to 500 lb. ft. torque (dry thread).

Recheck tightness of the cap nuts after initial run-in of 1 or 2 hours, and each 8 hours thereafter. A check for rim damage, tire damage, and a check for broken studs should also be made at this time.

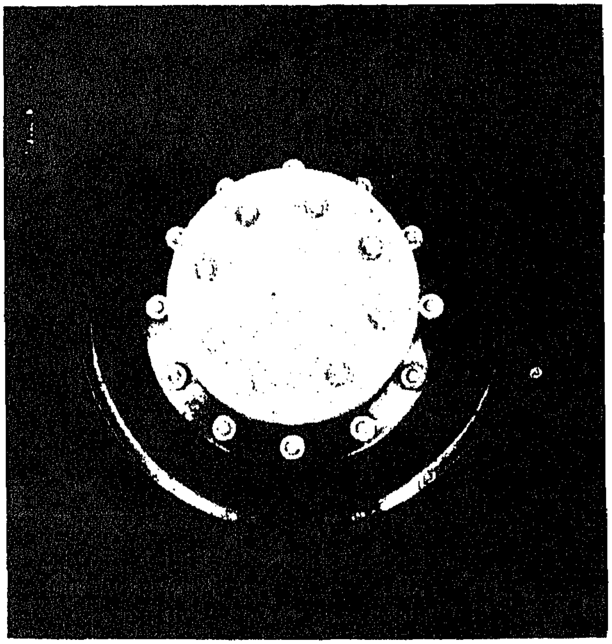


Fig. 14. Wheel Mounting Nuts

DO NOT MINIMIZE THE IMPORTANCE OF WHEEL MAINTENANCE. KEEP MOUNTING CLEAN AND TIGHT. THIS WILL INCREASE TIRE LIFE AND REDUCE OPERATING DOWN TIME.

In this adjustment section we have pointed out the various adjustments that can be made that will, in some cases, prevent serious problems and costly down time. Make it a practice to make periodic checks for the external leakage of engine oil, fuel, engine coolant, transmission oil, and axle lubricant. Also check to see that sheet metal hanger straps, mounting bolts, bellcranks, and clevises are all tight. Tighten hose clamps, fittings, filler plugs, drain plugs, loose bolts, nuts or screws, paying particular attention to the wheel nuts, axle, transmission, engine mounting bolts, hose connections, and axle tie rods. When tightening the various bolts, use the torque specified in the chart. (See Index.)

Remember preventive maintenance cuts operation expense and often prevents expensive delays.

INSTRUCTION PLATES AND DECALS

Some instruction plates and decals are attached with adhesive and may come loose. It is recommended that plates and decals so loosened be attached with self-tapping screws except on oil filters and like items where holes may not be drilled.

ance these filters must be cleaned or replaced at regular intervals to insure a long component life. The change periods listed below are for average conditions.

REMEMBER

Oil filter elements, replaced or cleaned as directed, mean a long machine life, minimum down time, and a saving of repair expense.

ENGINE FUEL FILTERS

The fuel filter and fuel strainer are mounted on the engine in the engine compartment. One-quarter pint of fuel should be drained daily from each to remove dirt and water accumulations. Drain cocks are provided at the base of each for this purpose. Install replaceable elements as directed in the Engine Maintenance Part. Detailed changing instructions are provided.

ENGINE LUBE OIL FILTER

Change the replaceable type filter element with each engine oil change. Detailed changing instructions are provided in the Engine Maintenance instructions.

MAIN HYDRAULIC SYSTEM FILTER

This filter is located in the hydraulic oil reservoir behind the operator's compartment. It may be removed for cleaning by reaching in the clean-out hole on top of reservoir and turning it from inlet connection.

To clean the MONEL element, swish in a non-inflammable cleaning solvent or use soft brush. Shake off excess solvent and blow away from inside out with compressed air. Inspect filter in a bright light to insure it is free from foreign material.

The filter element may be taken apart to facilitate a more thorough cleaning if necessary. Loosen and remove center bolt nut. Lift off top nut, cover and cover gasket. Separate centering tube from wire cloth insert. Reclean all parts in a non-inflammable cleaning solvent using a soft brush to remove all particles which cling to the parts. Inspect all parts for damage. Replace if necessary. Reassemble filter and install in reservoir.

The filter should be removed and cleaned the first 50 hours of operation and each 500 hours thereafter, or when any major overhaul to the cylinders, pump, or valve is performed. This is necessary or pump failures may result due to cavitations.

. Let oil cool before servicing. When cleaning bottom of reservoir, do not force dirt into suction lines.

cleaned after each 8 hours of operation. Remove top of filter body and filtering fibre. Swish in clean non-inflammable solvent, shake off excess, and blow away from inside out gently with compressed air. Replace fibre in filter body; reinstall cap.

TRANSMISSION HYDRAULIC SYSTEM BREATHER

Breather is located behind the operator's compartment on the main hydraulic tank. Service after 8 hours of operation. Swish in clean non-inflammable solvent, shake off excess, and blow away from the inside out with compressed air.

NOTE: Before attempting to replace or clean any filters, breathers, or drain plugs, the entire surrounding area must be wiped clean of grease or any foreign material. In servicing these systems, cleanliness is of the utmost importance.

WARNING: Do not use gasoline or any other volatile solvent such as naptha, benzene, etc., for cleaning. Less flammable fluids, such as kerosene or mineral spirits, must be used.

Lubrication is the most essential part of preventive maintenance. Different lubricants are required for different purposes. Complete lubrication at recommended intervals is a good insurance against costly breakdowns. Refer to the lubrication chart to locate the various points to be serviced. Before any servicing is performed, always wipe clean the grease fittings, plugs, or covers to prevent dirt or foreign material from entering.

Be sure the machine is setting level with the complete bottom of fork tines resting flat on the ground and THE ENGINE SHUT OFF.

STEERING HYDRAULIC SYSTEM FILTER

The steering hydraulic filter is mounted between the pressure return hose and the reservoir on the left rear of the main hydraulic reservoir. It has a check valve in the outlet line. The filter should be serviced after the first 50 hours of operation and each 200 hours thereafter, or when any major overhaul to the cylinders or steering pump is performed. Remove plug to drain; remove bolt and body. Remove element from body. Replace filter element;

TRANSMISSION HYDRAULIC SYSTEM FILTER AND STRAINER

The system filter is located in the return oil line to the transmission on the right side of the machine. Service from engine compartment. Remove bolt to remove body with element. Clean shell; replace head gasket and element. Turn bolt into head. Torque center bolt to 30 lbs. ft. torque. Replace filter element after the first 200 hours of operation and each 500 hours thereafter when changing oil.

Under dirty conditions, the filter element should be replaced and cleaned more often.

BREATHERS

Breathers are instlled for various components at the back of the main hydraulic tank to relieve any pressure that is built up by the heat generated in the lubricant through the operation of the machine. Service on these breathers is necessary and should be adhered to strictly. Failure to do this can result in seal and bearing failures.

AXLE HOUSING BREATHERS

Breathers should be kept free of foreign material.

Magnetic drain plugs are installed in the planetary hubs of each axle. These plugs perform the vital function of trapping small metallic particles that circulate in the lubricant through the gears and bearings, causing rapid wear and premature failure. Clean these plugs when changing lubricant.

WASHING INSTRUCTIONS

At the end of the work period, the machine should be thoroughly washed. Hose or wash away, with brush or rags if necessary any dirt and especially all salt that has adhered to machine. Inspect machine for sticks or any debris that has become entangled in hoses, electrical wiring, mechanical linkage or joints.

SERVICE EVERY 8 HOURS OF OPERATION

ALL GREASE FITTINGS
Refer to Lube Chart.
USE MULTIPURPOSE GREASE

AIR CLEANER
Check every 8 hours or more often as required. This is very important. Excessive exhaust smoke and loss of power can be caused by a dirty air cleaner. Squeeze bladder vacuator and hold until all dust drops out. See 200-Hours service.

AIR RESERVOIR
See Brake System.

BATTERIES
Keep terminals clean and tight. Keep fluid level above plates and separators. Use only clean distilled water.

ENGINE AND ACCESSORIES
Refer to engine operation and maintenance for instructions on lubrication, maintenance of engine and accessories, and choice of engine oil.

FUEL
Fill fuel tank with clean oil. Refer to engine manufacturer's operation maintenance manual for choice of fuel oil. See 50-Hour Service. See capacity section.

MAIN AND STEERING HYDRAULIC SYSTEM
Check level each 8 hours by unscrewing dipstick at top of reservoir. If level is low, bring up to full mark. Add only clean make-up oil through dipstick opening. For temperatures above 0° F., use SAE-10W oil with anti-foam characteristics, for operation in temperatures below 0° F. to −25° F., use type "A," suffix "A" automatic transmission fluid. DO NOT MIX OILS. The original oil must be drained at 500 hours.

PILLOW BLOCK
The pillow block is located immediately to the front of the main pivots. Lubricate with a hand grease gun at the fitting on top of the pillow block. Grease should be pumped in until it appears in a fair quantity at the pressure relief orifice on top of the fitting. The pillow block bearings are not properly lubricated until the new grease is seeping out of the relief orifice. Use MULTI-PURPOSE GREASE SPARINGLY. See overhaul of pillow block.

RADIATOR
Check coolant level each 8 hours; refill as required by TB ORD 651.

TRANSMISSION HYDRAULIC SYSTEM
Check oil level each 8 hours. Refer to Transmissio and Torque Converter Section for detailed instructions If level is low, bring up to full with clean make-up oil Fill plug is located at right sump. Use type "A" suffix A AUTOMATIC TRANSMISSION FLUID. The original oil must be drained at 500 hours. See 500-Hour service.

WHEEL NUTS
See Adjustment Section.

SERVICE EACH 50 HOURS OF OPERATION

AXLES
Check lubricant level each 50 hours and keep level u to bottom of level hole. To check the hypoid differential and the planetary hubs, the machine should be ru first, then allowed to stand on level ground. After 5-minute interval, which allows the lubricant to settl to its level, proceed as follows:

Remove oil filler plug in rear of housing bowl of eac axle for inspection. If lubricant level is below botton opening of the filler hole, add necessary lubricant. Re install plug. For planetary hubs (4 points) rotate whee until oil level mark in wheel and thrust cap is paralle with ground. Remove level plug; if lubricant level i below opening, add necessary lubricant. Re-install plug DO NOT OVERFILL—SEE LUBE ORDER FO LEVEL PLUGS. Use Multi-purpose gear lube (AP service GL-4, CRS-10 level grade or better), SAE-90 or Rockwell-Standard specification 0-64, Grade 90 viscosity. DO NOT ADD DIFFERENT TYPE OF LUBRICANT. The original lubricant must be drained a 300 hours of operation. See 1000-hour service.

FUEL TANK
Open drain valve to remove accumulated water an sediment.

POWER CLUSTER
Check level of brake fluid in each power cluster ever 50 hours of operation. If necessary, add brake fluid t within ½ to ⅜ inch. Change fluid if it is materiall darker in color than new fluid, if it is watery in consistency, if it is comparatively odorless, or if it fails t provide a thin lubricating film when rubbed betwee fingers. Use super heavy duty brake fluid, SAE 70 R-3
CAUTION: Never add mineral base oils to the brak hydraulic system. This will cause rapi deterioration of rubber parts in the system

PROPELLER SHAFTS
There are three propeller shafts, from torque converte to transmission, from transmission to rear axle, fron pillow block to front axle. Each shaft has 3 points o lubrication, one on each spider and bearing assembl and one on the slip yoke assembly (total 9 points). US A HAND GUN AND APPLY MULTI-PURPOS GREASE SPARINGLY.

pider and bearing assembly. USE A HAND GUN AND APPLY MULTI-PURPOSE GREASE SPARINGLY. See overhaul of ball slip joint.

SERVICE EACH 200 HOURS OF OPERATION

AIR CLEANER

Service the air cleaner every 200 hours.

Remove vacuator and rear cover. Dump out dust and re-install. Remove front cover. Lift out element; clean with compressed air (do not exceed 100 psi) from the clean air side or wash in filter cleaner solution. An even bright pattern of light through the element, when a light is held inside will indicate element is thoroughly clean.

Install element and cup. See 1000-Hour service.

CAUTION: Always cover engine intake pipe while air cleaner is being serviced. DO NOT PUT OIL IN CUP.

STEERING HYDRAULIC SYSTEM RETURN FILTER

(See Filter Section)

SERVICE EACH 500 HOURS OF OPERATION

MAIN HYDRAULIC SYSTEM FILTER

(See Filter Section)

TRANSMISSION HYDRAULIC SYSTEM

Change oil each 500 hours. See Filter Section.

Refer to transmission and torque converter sections of this manual for detail changing instructions.

Fill plug located at right oil sump. See capacity section.

Use type "A" SUFFIX A AUTOMATIC TRANSMISSION FLUID.

SERVICE EACH 1000 HOURS OF OPERATION

AXLES

Drain lubricant in each hypoid differential (2 points) and planetary hubs (4 points) each 1000 hours. Draining is best accomplished immediately after machine has been operated. The lubricant is then warm and will flow freely, allowing full drainage in minimum time. To drain differential, unscrew plug at bottom of housing bowl. To fill, reinstall bottom plug, remove rear filler plug, and fill until lubricant seeps out opening. Reinstall plug. To drain planetary hubs, rotate wheel until drain hole plug is at the bottom of axle. Remove plug and allow ample time for the old oil to run out; reinstall plug. To fill, rotate wheel until oil level mark on end cap is parallel with ground. Remove level plug and fill until lubricant seeps out opening. Reinstall plug. DO NOT OVERFILL—SEE LUBE ORDER FOR LEVEL PLUGS.

UNDER NO CONDITION SHOULD MACHINE BE MOVED WITH NO LUBRICANT IN AXLES. Use Multi-purpose Gear Lube (AP1 Services GL-4,

AIR CLEANER

Replace element after every 1000 hours of operation. Inspect tubes in bright light. Dust deposits may be removed with stiff fiber brush. Before reassembly, inspect outside case for cracks and see that all connections are tight. Inspect all gaskets for damage.

CAUTION: Always cover engine intake pipe while air cleaner is being serviced. Keep spare parts on hand to insure a minimum of down time.

SERVICE EACH 3000 HOURS OF OPERATION

STEERING AND MAIN HYDRAULIC SYSTEM

Oil should be changed each 3000 hours, or when any major overhaul to the cylinders, pump or valve is performed. When operating under severe dusty or dirty conditions, this system should be cleaned and refilled more often to prevent excessive wear or premature failure of component parts.

Drain and refill system as follows:

Draining should be accomplished after operating machine, while oil is still warm. Warm oil flows more freely and carries more dirt and sludge with it. Attach 1-inch pipe thread hose from brass drain valve to suitable container to keep machine free of spilled oil. Open drain valve.

Remove cover and breather from top of reservoir. Clean breather. See Filter and Breather section.

Remove MONEL filter element and clean thoroughly; reinstall. See Filter and Breather section.

After oil has stopped draining, clean all dirt and sludge from bottom of reservoir, being careful not to force dirt into suction lines. Refill reservoir nearly to top with clean hydraulic oil. Reinstall cover and breather, replace gasket, and tighten bolts evenly. Check to see that controls (lift arms and fork) are in neutral position; then start engine. Idle for a few minutes. Operate machine by raising, lowering, and dumping the fork until oil ceases to foam. This will "bleed" system, forcing trapped air to escape through reservoir breather. After oil has ceased to aerate, add oil through dip stick opening to bring level to full mark.

Check all connections for leaks. NEVER USE ANY FLUSHING OIL, COMPOUNDS, or SOLVENTS FOR CLEANING THIS SYSTEM.

For operation in temperatures above 0° F., refill with SAE 10 oil with anti-foam characteristics. For operation in temperatures below 0° F. to −25° F., refill with Type "A" SUFFIX-"A" AUTOMATIC TRANSMISSION FLUID. DO NOT MIX OILS. See Capacity section.

STEERING GEAR

Lubricate when overhauled or at 3000-hour interval. Use MULTI-PURPOSE GREASE. Capacity of overhaul gear is 1½ pounds of grease.

The attached welding procedure has been written to permit the average welder to repair or replace a part or parts which necessitates the requirements for welding.

We do not use nor do we recommend welding by the metal inert gas (MIG) process for field or shop repair or replacement.

The 3000M machine has been constructed with various types of steel. One of these steels is known as "high strength constructional steel." This is defined as "ASTM A-441."

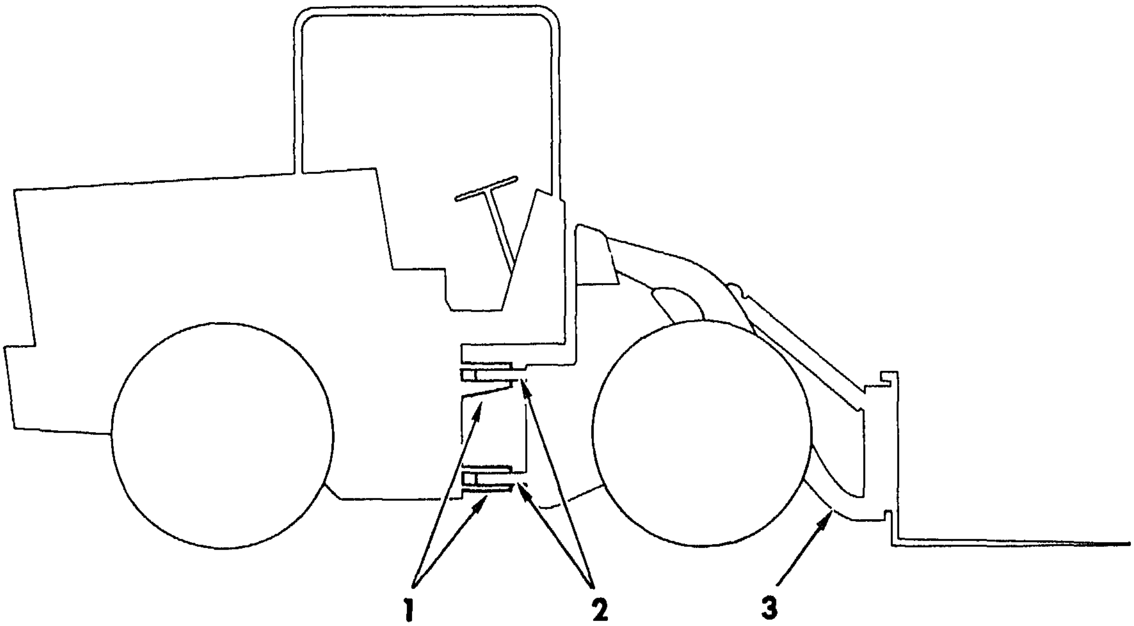
ASTM A-441 steel is located in the following areas o the machine proper: No. 1, Rear Frame Pivot Section No. 2, the Front Frame Pivot Section and No. 3, Sid Plates of both Lift Arms.

Figure A shows the exact location of this steel in rela tion to the machine as a whole.

We recommend all welding pertaining to the repair o this unit, be done with A.W.S. E-7018 electrodes.

Military Specification: MIL-E-22200/1, MIL 701

ASME: F-4, A-1 AWS A5.1-64T, ASTM A233-64T



1. Rear Pivot 2. Front Pivot 3. Lift Arms

Fig. A

PROTECTIVE EQUIPMENT

HEAD SHIELD

To protect the operator's face and eyes from the direct rays of the arc, it is essential that a head shield be worn. The head shield is constructed with a head band. Connected to the band is a front shield containing a small glass window to absorb the infrared rays, ultra violet rays, and visible rays eminating from the arc.

Special goggles should be worn by those working close to the welding arc to protect their eyes from occasional flashes.

GLOVES, APRONS AND OTHER CLOTHING

Operators and helpers should wear protective gloves, aprons and sleeve protectors to guard against sparks, globules of molten metal which are present in the welding area. This clothing should be composed of flexible woven asbestos and a fire-resistant material.

ELECTRODES, TYPE A.W.S.-E7018

Electrodes exposed to damp atmospheric temperature pick up moisture, which when excessive will render ther unfit for use.

Electrodes should be stored as received in sealed con tainers at 70° to 110°F. After containers have been open ed, the electrodes should be stored in an oven at 350 to 450°F.

Electrodes which have been contaminated by moistur should be heated in a controlled oven to a temperatur of 180°F. Hold this temperature for a period of on hour. Raise temperature to 600°F. and hold for 30 t 60 minutes. Visually inspect electrodes for cracks an broken coating. Discard if necessary. Restore electrode at 350° to 450°F.

Remove all foreign matter such as paint, oil, grease and dirt from area to be repaired. This is essential to insure correct fusion of the two metals during welding.

Remove the old weld bead from the area to be rewelded or repaired.

This may be accomplished by one of two methods or a combination of both, whichever is suitable to the person performing the work.

GRINDING METHOD

Position the grinding wheel so the edge of the wheel comes in contact with the area to be cleaned. Apply pressure and remove the old weld. Depending on the area to be cleaned, it may be necessary to use a disc grinder to finish dressing the surface.

The depth of the grinding depends on the amount of weld which is present in the area to be repaired. This depth when finished, should be down to parent metal to form a good base for the new weld.

Joining a new weld to an old weld presents no problem when the old weld is considered to be parent metal and is cleaned in the same manner as the original pieces welded together.

An example of this is as follows: We have two pieces of metal held together with a bead of weld ten inches long. The weld cracks and is three inches long. The old weld should be removed from the entire length of the crack and beyond the crack to insure this defect has been completely removed. It is not necessary to remove the complete ten inch weld. (See Fig. B).

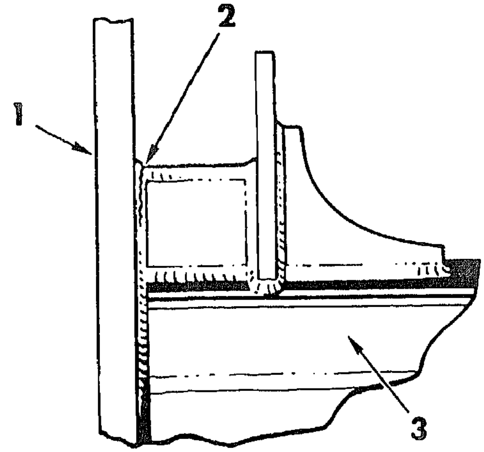
SCARFING METHOD

Scarfing is a means of using a carbon arc or flame torch to melt and remove the old weld from the area to be repaired.

This method also requires using a power grinder to remove beads of cooled metal and slag from the reweld area.

Beveling old work prior to rewelding is not necessary since removing the old weld will automatically include a grinding chamfer.

Replacement steel should be chamfered prior to welding within 10% of expected bead width and only as deep as required to eliminate unnecessary build-up.



1. Lift Arm
2. Crack
3. Crossmember

Fig. B

REPAIR WELDING

Repair welding is different than actual new machine fabrication welding.

Many factors such as material preparation, material positioning, the use of jigs and fixtures and many others govern original machine fabrication welding versus actual field repair welding.

After following the procedures outlined in the "Material Preparation" portion of this section, the following welding instructions should be followed:

TEMPERATURES

Welding repairs to the machine may be done at any ambient temperature as long as the following information is adhered to.

No welding should be done when the temperature of the base metal is lower than 0°F. The base metal should be heated to at least 70°F. adjacent to the weld area.

The area adjacent to the pivot race located on the pivot crossmember is the only area which requires special temperature control. (See Repair of Pivot Section).

There is no need to control interpass temperature since the heat incurred by the first pass is sufficient to heat the base metal for the second pass. This is also governed by the time elapsed by the operator between welds.

Voltage Required: See Chart Fig. C.

Amperage Required: See Chart Fig. C.

Size	Volts	Range	Optimum	Vertical	Overhead
3/32"	21-24	70-110	100	70-100	70-110
1/8"	21-24	90-160	140	90-135	90-160
5/32"	22-25	130-220	170	110-160	130-200
3/16"	23-26	200-300	250	150-220	200-275
7/32"	23-26	250-350	300	—	—
1/4"	24-27	300-400	350	—	—

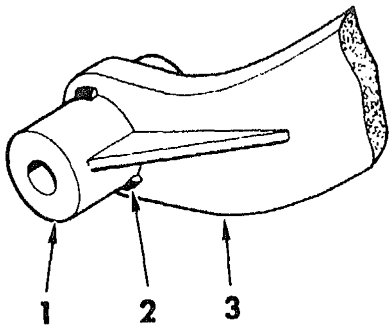
Fig. C

TACK WELDING

Tack welding is used to join two loose pieces of metal prior to finish welding. Should the piece require welding on both top and bottom sides, both sides have to be tacked.

Adding a new section of metal to a stationary section requires tacking both ends of the new piece to the existing piece. Center tack welding is also necessary and depends on the length between the end tack welds.

Tack welding is not required in repair work where both ends of the work are held in position by an old weld.



1. Boss 2. Tack Weld 3. Lift Arm

Fig. D

The following is an example to tack weld the lift arr pivot boss in position. The welds have broken loos on both sides of the arm. Both the boss and arm hav been cleaned to remove the old weld. The boss ha been aligned with its corresponding boss on the oppo site lift arm and you are now ready to tack weld i position. See Fig. D.

Using the chart in Fig. C, set the welding machine t the correct voltage and amperes required. Position th electrode in position and drop your head shield. Strik an arc and run a bead about ½ inch long on top anc on the bottom of the boss joining the boss to the lif arm. Tack weld the opposite side in the same manner

Remove the slag from the tack weld and proceed wit the finish welding.

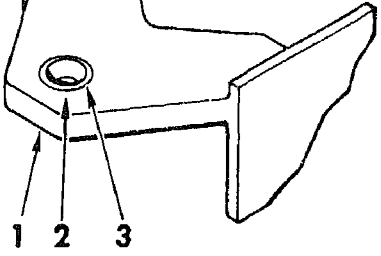
MAIN PIVOT REPAIR

The main pivot area may be repaired or replaced whe necessary. It requires no special welding instruction except a special temperature control is necessary.

The area adjacent to the outer race should not be hea ed above a temperature of 400°F. This may be d termined by using a 400°F. tempilstick.

Mark the entire circumference of the outer bearin race with the tempilstick, both top and bottom if bot sides are to be repaired. When the mark melts, th specified temperature (400°F.) has been reached. A low the workpiece to cool sufficiently and remark th outer race before more welding is done. See Fig. E

After completing the repair, the outer surfaces of th metal should be ground with a disc grinder and paintec

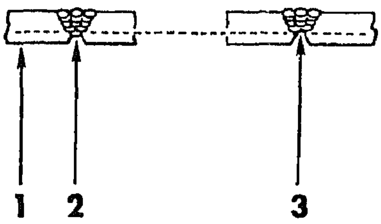


1. Crossmember 2. Outer Circumference
3. Race

Fig. E

WELDING BOTH SIDES

After completion of welding the first side, see Fig. F, the second side or bottom of the metal should be ground up into the first weld as illustrated in Fig. F. This will insure correct fusion of second weld to first weld.

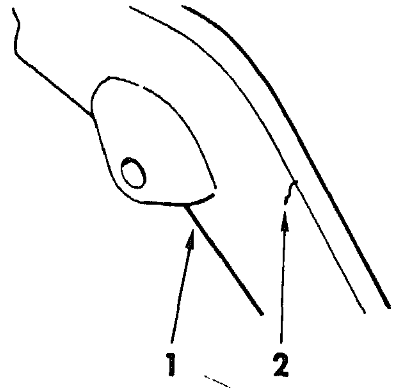


1. Base Metal 2. First Weld
3. Grind Depth

Fig. F

LIFT ARM REPAIR

Fig. G shows a crack in the side of the lift arm and across the top about ½ inch. Grind out the complete crack going beyond the crack into parent metal.
The depth of the grind, the position of the arm and the electrode size will determine how the operator will repair this section.



1. Lift Arm 2. Crack

Fig. G

GROUNDING

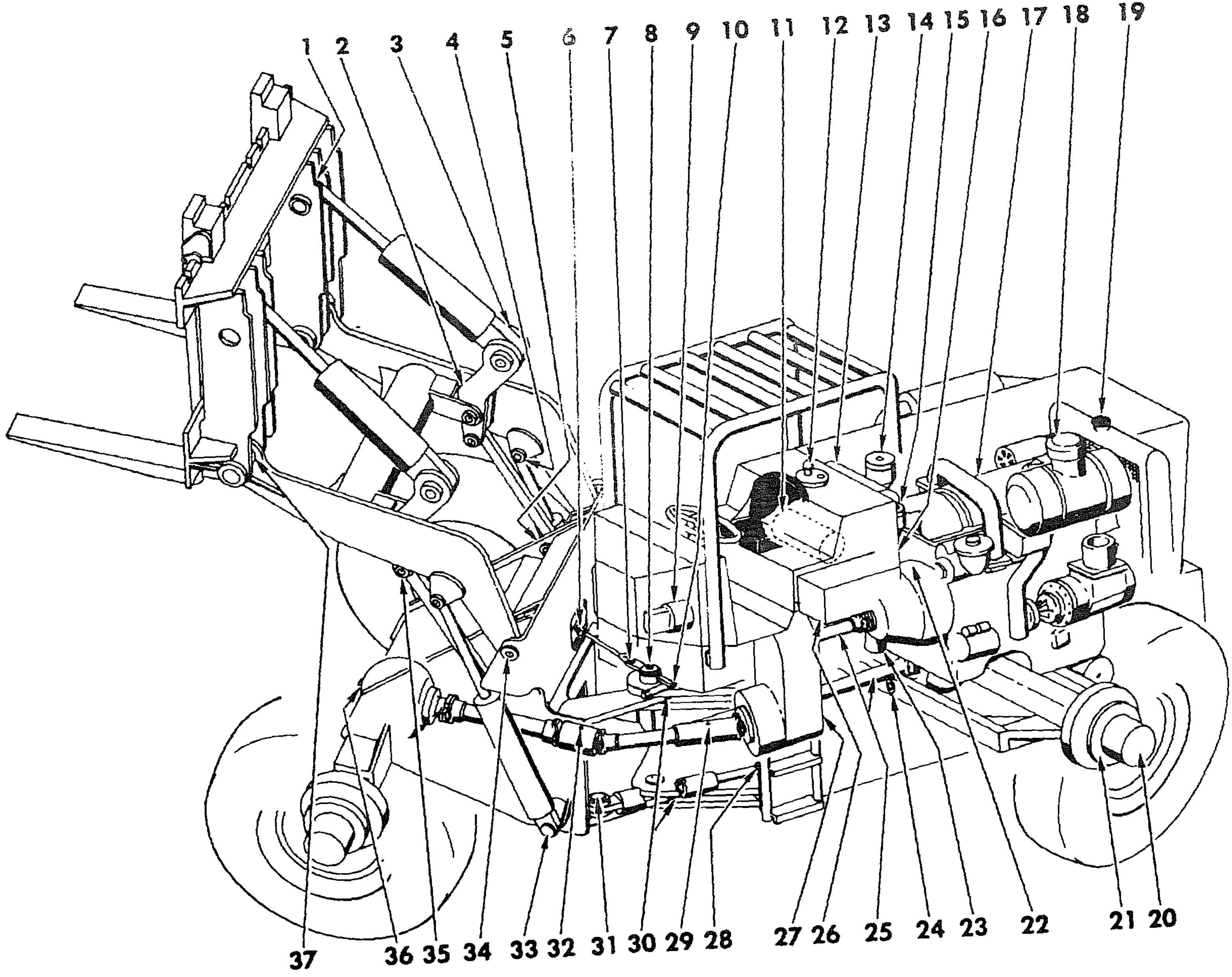
Place the ground clamp as close to the area to be welded as possible. This is necessary for two reasons.

No. 1—You get a better weld deposit due to the lack of electrical resistance between the electrode and the ground clamp.

No. 2—It is very possible to pit bearings and cause premature failures in the bearing and cone. Scoring of the hydraulic cylinder tubes causing packing failure.

An example of correct grounding to prevent the welding current from arcing is as follows:

The area to be welded is the lifting arm. The ground clamp should be placed on the lifting arm that is to be welded. "Do Not Ground On the Ladder Attached To the Rear Frame."



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TROJAN TRACTOR SHOVEL
MODEL 3000M LUBRICATION CHART

NT	IDENTIFICATION	No. of POINTS	TYPE of LUBRICANT
1	Fork Lift Cylinder Head	2	MPG
2	Bellcrank Pivot	2	MPG
3	Fork Lift Cylinder Pivot	2	MPG
4	Lift Cylinder Head	2	MPG
5	Leveling Arm Pivot	2	MPG
6	Steering Rod End	1	MPG
7	Steering Bellcrank End	1	MPG
8	Steering Bellcrank Pivot	1	MPG
0	Steering Tie Rod	2	MPG
2	Main & Steering Hydraulic System Oil (Check Level & Clean Breathers)	1	EO
3	Air Reservoir	2	Drain
6	Breather's—Trans. & Steer. Hydraulic	1 Ea.	Clean
7	Engine Oil — Filter (Refer to Engine Mfgrs. Maintenance Manual for Change Intervals)	1	Check EO*
8	Air Cleaner	1	Check
9	Radiator (50-50 Solution of Water & Anti-Freeze Per Fed. Spec. O-A-548)	1	Check
3	Fuel Filter	2	Drain
4	Axle Cradle Pivots	2	MPG
6	Batteries	12	Check
8	Steering Cylinder Head	2	MPG
0	Main Pivots (Upper & Lower)	2	MPG
1	Steering Cylinder Pivot	2	MPG
2	Pillow Block	1	MPG
3	Lift Cylinder Pivots	2	MPG
4	Lift Arm Pivots	2	MPG
5	Leveling Arm at Bellcrank Pivot	2	MPG
7	Fork Pivots	2	MPG

INTERVAL HOURS	POINT	IDENTIFICATION	No. of POINTS	TYPE of LUBRICANT
50	9	Power Cluster (Under Access Hole in Front Shroud)	2	HBA
	20	Planetary Oil Level	4	Check Lube Oil
	25	Propeller Shafts	9	MPG
200	15	Steering Hydraulic System Return Filter	1	Change
	18	Air Cleaner (Element)	1	Clean
500	11	Main Hydraulic System Filter	1	Clean
	14	Transmission Hydraulic System Filter (Change when Changing Oil)	1	Change EO
	22	Transmission Converter Fill	1	EO
	27	Transmission Converter Drain	1	EO
1000	18	Air Cleaner (Element)	1	Change
	21	Planetary Drain & Fill	4	Change Lube Oil
	29	Slip Joint	3	MPG
	36	Differential Drain & Fill	2	Lube Oil
3000	12	Main & Steering Hydraulic System Oil	1	Change EO

KEY TO SYMBOLS

EO — Engine Oil, Mil-L-2104, OE-30*, OES*, OE-10
MPG — Grease, Automotive, Mil-G-10924
Lube Oil — Lubricating Oil Universal, Grade 90, Mil-L-2105
HBA – Brake Fluid (Conforms to MIL-H-13910)

MAIN HYDRAULIC SYSTEM

The main hydraulic system consists of a reservoir with an integral filter, main hydraulic pump mounted on the torque converter, main control valve, two double acting lift and fork control cyinders, and the connecting hoses and fittings. The main control valve is mounted on the front of the reservoir and to the right of the operator. It incorporates three relief valves and two void control valves. A breather is installed in the cover of the hydraulic reservoir with a check valve mounted under the breather.

The main hydraulic system uses OE-10 motor oil.

STEERING HYDRAULIC SYSTEM

The steering hydraulic system is supplied from the same hydraulic reservoir that supplies the main hydraulic system. It consists of a steering pump mounted on the torque converter, a steering demand valve mounted under the reservoir, two steering cylinders mounted between in the front frame section, an external filter, connecting hoses and fittings. The steering system uses OE-10 motor oil.

TRANSMISSION HYDRAULIC SYSTEM

The transmission hydraulic system consists of an oil supply in the transmission sump, a charging pump and a pressure regulating valve both mounted on the torque converter, a control valve mounted on the transmission, an oil cooler integral with the radiator, and the connecting hoses and fittings. The transmission hydraulic system uses OE-10 motor oil.

Any hydraulic system requires regular attention regardless of design. The Trojan hydraulic systems contain the most modern components present day engineering and manufacturing can provide. As these systems are the heart of your machine, a thorough preventive maintenance program, as outlined in the lubrication and service section of this manual, is of paramount importance.

MAIN HYDRAULIC SYSTEM

SERVICE AND REPAIR

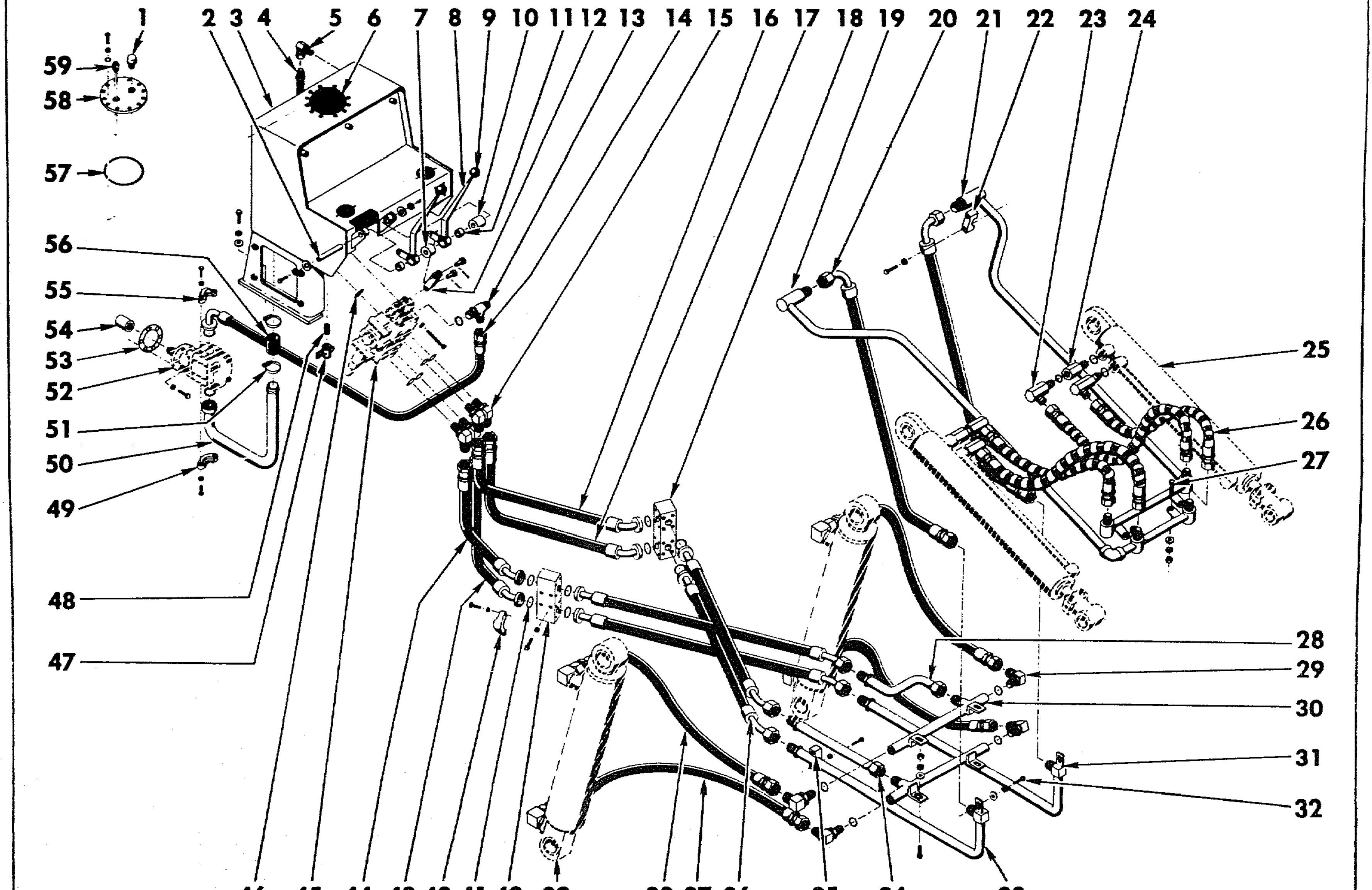
There may be occasions when the main hydraulic system will not function properly. This is usually due to a low hydraulic oil level or to dirt or foreign matter in the system. In general, this will be indicated by extremely sluggish cylinder action; in some cases a cylinder will be completely inoperative. especially when the engine is idling. When this trouble occurs, a careful inspection should be made of all external hose connections and hoses for leakage. Check the oil level in the hydraulic reservoir with the dip stick. If the level is low, fill the reservoir as directed in the Lubrication section. If evidence of leakage is found, replace the defective part or tighten a loose connection. Take care not to over-tighten connections since this may damage the "O" ring seal and increase leakage. If inspection does not reveal an obvious cause of the trouble or if the correction of obvious troubles found does not correct the system trouble, it may be necessary to disassemble the individual units of the system. To isolate the trouble to the unit at fault, proceed as directed in the Trouble Shooting section.

TROUBLE SHOOTING

Disconnect a hose at the rear of one of the lift cylinders, operate the lift arm control lever, and observe the flow of oil from the open hose and cylinder opening.

NOTE: Always provide a container of sufficient size to catch the flow of hydraulic oil. Do not reuse oil collected. Fill the reservoir with fresh clean oil.

If the flow volume of the oil is small, either the pump, control valve, lift cylinder, or crossover pipe is clogged or defective. Close this connection and disconnect the outlet hose from the pump. Check the flow of oil from the pump. In the same manner, check other points in the hydraulic circuit until the fault is isolated to the defective component. See the Main Hydraulic System illustration to determine the direction of oil flow in the system. If the component at fault is determined, continue to trouble shoot the component as follows:



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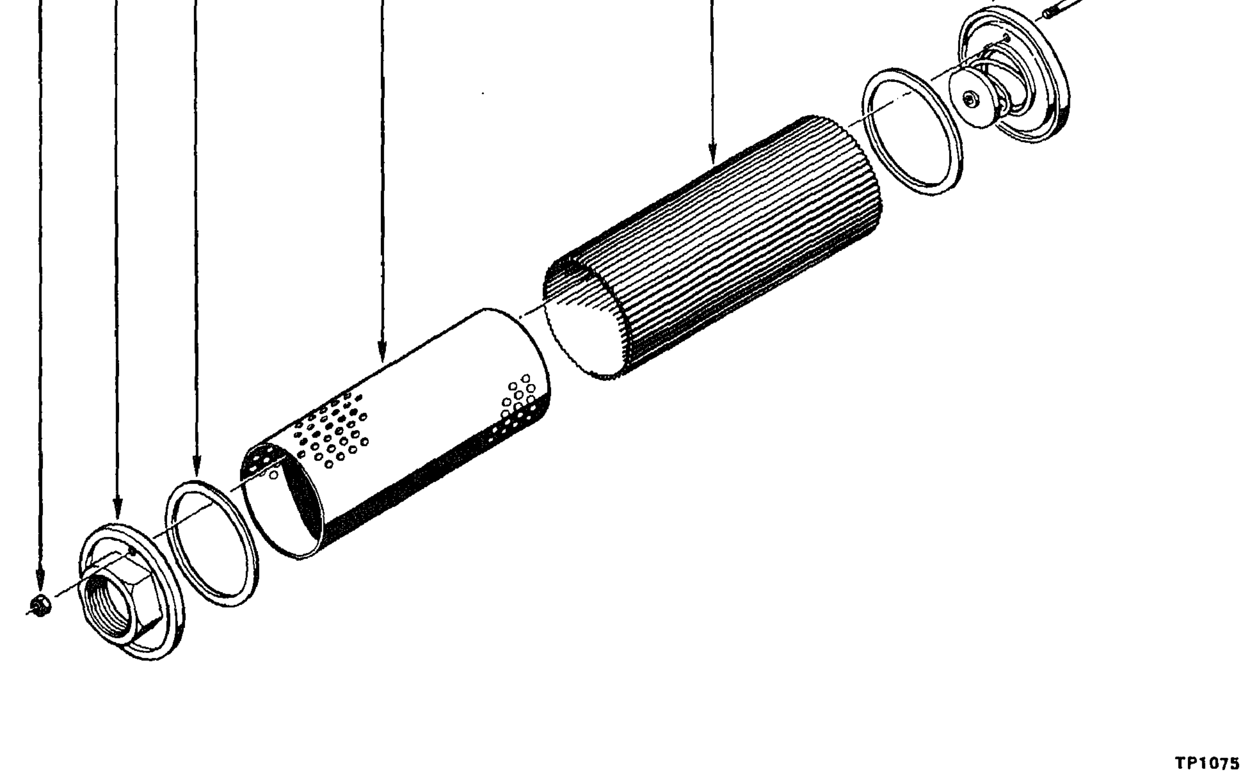
Item	Part No.	Description	No. Req'd.
1	2057236	Breather	1
2	2060407	Shaft	1
2A	2031563	Bolt, Shaft to Reservoir Assy.	2
2B	2031395	Washer, Lock	2
2C	2032964	Washer, Flat	2
3	2067797	Reservoir Assy.	1
3A	2031559	Bolt, Reservoir to Frame	10
3B	2031395	Washer, Lock	10
3C	2036820	Washer, Flat	10
4	2003093	End, Hose	1
4A	2045839	Hose	1
5	2057545	Valve, Check	1
6	———	Filter (Inside Tank) (See Sep. Illus.)	
7	2060408	Spacer	1
8	2058039	Lever Assy., Controls	2
9	2033274	Ball Knob	2
10	2060409	Spacer	1
11	2057370	Bushing	2
12	2059077	Link, Lever to Valve	4
12A	2010556	Pin, Clevis	4
12B	2031768	Pin, Cotter	4
13	2064551	Tee, Adapter	1
13A	2031964	"O" Ring	1
14	2067685	Hose	1
14A	6951993	End, Hose at Pump	1
14B	6951990	End, Hose at Tee	1
14C	2033307	"O" Ring	1
15	2031941	Elbow, Adapter, 45°	4
15A	2031964	"O" Ring	4
16	2067682	Hose	1
16A	6951992	End, Hose at Junction Block	1
16B	6951990	End, Hose at Elbow	1
17	2067681	Hose	1
17A	6951992	End, Hose at Junction Block	1
17B	6951990	End, Hose at Elbow	1
18	2058348	Block, Junction, L.H.	1
18A	2031498	Bolt, Block to Frame	4
18B	2031392	Washer, Lock	4
19	2058744	Pipe Assy., R.H.	1
20	2067695	Hose	2
20A	6951998	End, Hose at Pipe Assy.	2
20B	6951990	End, Hose at Tube Assy.	2
21	2058751	Pipe Assy., L.H.	1
22	2068076	Block, Pipes to Arms	2
22A	2031524	Bolt, Block to Lift Arm	4
22B	2031393	Washer, Lock	4
23	2049310	Joint, Swivel, 90°	4
23A	2031963	"O" Ring	4
	6955064	Kit, Repair, Swivel Joint	1
24	2063949	Fitting, Extension, "O" Ring	2
24A	2031963	"O" Ring	2
25	———	Cylinder, Fork (See Sep. Illus.)	
26	2067677	Hose	4
26A	6951986	End, Hose	8
27	2031521	Bolt, Lift Arm Pipe to Lift Arms	4
27A	2031393	Washer, Lock	4
27B	2032962	Washer, Flat	4
27C	2031619	Nut	4
28	2060459	Tube Assy., L.H.	1
29	2031929	Elbow, 90°	8
29A	2031963	"O" Ring	8
30	2060410	Tube Assy., Crossover	2
30A	2031523	Bolt, Crossover to Frame	4
30B	2031619	Nut	4
30C	2031393	Washer, Lock	4
30D	2032962	Washer, Flat	4
31	2060457	Tube Assy., L.H.	1
32	2031475	Bolt, Tube to Frame	2
32A	2031391	Washer, Lock	2
32B	2032960	Washer, Flat	2
33	2060456	Tube Assy., R.H.	1
34	2060458	Tube Assy., R.H.	1
35	2058902	Block, Hold-Down	4
35A	2031480	Bolt, Block to Frame	12
35B	2031391	Washer, Lock	12
36	2067696	Hose	4
36A	6951999	End, Hose at Tube Assy.	4
36B	6951991	End, Hose at Junction Block	4
37	2067676	Hose	2
37A	6951986	End, Hose	4
38	2067671	Hose	2
38A	6951986	End, Hose	4
39	———	Cylinder, Hoist (See Sep. Illus.)	
40	2059154	Block, Junction, R.H.	1
40A	2031498	Bolt	4
40B	2031392	Washer, Lock	4
41	2033306	"O" Ring	8
42	2033316	Flange, Half	16
42A	2031500	Bolt	32
42B	2031392	Washer, Lock	32

Never leave operators seat with the arms raised.

Item	Part No.	Description	No. Req'd.
43	2067683	Hose	1
43A	6951992	End, Hose at Junction Block	1
43B	6951990	End, Hose at Elbow	1
44	2067684	Hose	1
44A	6951992	End, Hose at Junction Block	1
44B	6951990	End, Hose at Elbow	1
45	———	Valve, Main Control (See Sep. Illus.)	
45A	2062393	Bolt, Valve to Hydraulic Tank	3
45B	2031395	Washer, Lock	3
46	2035394	"O" Ring	1
47	2012108	Valve, Drain	1
48	2033644	Nipple	1
49	2033318	Flange, Half	2
49A	2031521	Bolt	4
49B	2031393	Washer, Lock	4
50	2060242	Tube Assy., Suction	1
50A	2033308	"O" Ring	1
51	2032040	Clamp, Hose	2
52	———	Pump (See Sep. Illus.)	
52A	2044343	Bolt, Pump to Converter	6
52B	2031391	Washer, Lock	6
53	2033267	Gasket	1
54	2043819	Adapter, Pump Drive	1
55	2033317	Flange, Half	2
55A	2031521	Bolt	4
55B	2031393	Washer, Lock	4
56	2059375	Hose	1
57	2052323	"O" Ring	1
58	2063720	Plate Assy., Cover	1
58A	2031450	Bolt, Cover to Tank	12
58B	2032959	Washer, Flat	12
58C	2049479	Washer, Stat-O-Seal	12
59	2058169	Dipstick Assy.	1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FILTER ELEMENT ASSEMBLY

Item	Part No.	Description	No. Req'd.
A	2065055	Element Assy., Filter	1
1	2031863	Locknut	4
2	6951734	Cover Assy., Top	1
3	6951737	Gasket	2
4	6951740	Core, Perforated Center	1
5	6951741	Element, Replaceable	1
6	6951743	Cover, Bottom	1
7	6951742	Rod & Nut Assy.	2

trol Valve Cylinder Relief Valve.
See Check Valve Test and Overhaul.
See Void Control Valve Overhaul.

Reservoir Filter—See Cleaning Reservoir Filter.

Main Hydraulic Pump—Replace defective pump.

Lift Cylinders—See Adjustment of Cylinder Packing. Refer to Instructions on How to Check Hydraulic Cylinder Packings by Using a Simple Flow Test on the Machine.

See Overhaul of Lift Cylinder.

Fork Cylinders — See Adjustment of Cylinder Packing.

Refer to Instructions of How to Check Hydraulic Cylinder Packings by Using a Simple Flow Test on the Machine.

See Overhaul of Fork Cylinder.

Hydraulic Reservoir—See Replacement of Breather and Check Valve.

NOTE: Before removal of any component, drain the hydraulic reservoir. Discard used oil. After repair or service is completed, refill the reservoir and system with new oil. See Lubrication and Service section.

ADJUSTING LIFT AND FORK CYLINDER PACKING

The hydraulic cylinders are so constructed that no adjustments are necessary other than to tighten the rod packing if oil leaks excessively.

IMPORTANT: In following these procedures, refer to the Lift and Fork Cylinder illustration.

emerges from the cylinder. Install the setscrew (13) and lockwasher (13A). This compensates for packing growth and allows the wiper seal to remove dirt and other foreign mattter from the piston rod as it is drawn into the cylinder. The rod packing is the chevron type and is made up in sets of neoprene rubber and phenolic rings. (See Fig. 15):

FORK CYLINDER

Remove the setscrew (15), lockwasher (15A). Adjust the rod packing by turning the packing nut so a slight film of oil adheres to the piston rod at all times as it emerges from the cylinder. Install the setscrew (15) and lockwasher (15A). This compensates for packing growth and allows the wiper seal to remove dirt and other foreign matter from the piston rod as it is drawn into the cylinder. The rod packing is the chevron type and is made up in sets of neoprene rubber and phenolic rings. (See Fig. 15).

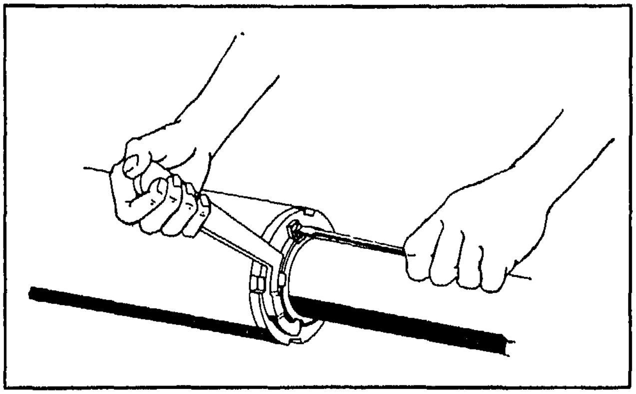


Fig. 15. Rod Packing Adjustment

the trouble may be thought to be caused by oil leaking past some defective cylinder packings, and a quick, reliable check without taking the cylinders all apart, can be a real help to the mechanic. The test, which can be employed on any double-acting cylinder, will show just which cylinder packing is giving trouble and just how bad it is, or whether none are at fault and the trouble is somewhere else in the system. Since piston packings and cylinder bores cannot be seen to be checked visually for defects, the whole idea is to determine the working condition of any cylinder by finding out if any oil, and how much of it, is going past the piston.

In making this spot check, several things should be kept in mind. First, the hoist cylinders and the fork cylinders on the machine are circuited together in pairs through piping tees that are provided in the hydraulic system. That is to say, the same or matching ports on the lift cylinders (and the same thing is true of the fork cylinders) are piped to a tee from which a single line goes to the main hydraulic control valve. One bad cylinder will affect the opposite cylinder and make it appear to be defective in operation, also, because of displaced oil feeding over to it through the system. That is precisely why the cylinders should be tested only one at a time.

Second, the principle of the test is as follows. With the cylinder bottomed out in either fully extended or retracted position and under hydraulic pressure in that position, uncouple the hose fitting from whichever happens to be the return port (the one not under pressure). It follows that any oil coming out of the opened return port MUST have been forced past the piston packing from the pressure side. Normally, a good cylinder and packing set-up will show no oil coming through, not even oil drips. Deteriorated packing is usually indicated by a small oil flow. Experience to be gained in relating the amount of oil flow to the estimate of probable damage will be of value to the mechanic as he goes along. The oil can be run into a container to measure the amount of flow over a short time period, usually a maximum of 10 seconds under valve by-pass pressure, to calculate amounts for longer periods (if desired).

Third, the hydraulic valve controls should be operated during the tests with due care to avoid false motions, because it is essential that the right control be moved in the right direction, and at the right time.

Fourth, the flow test should not be considered to be infallible. This simple check will not point up all troubles. Troubles such as internal cylinder scoring cylinder tube, or shifting packing due to a piston assembly coming apart cannot be expected to be successfully indicated.

FORK CYLINDERS

1. Move the fork control lever to "TILT-BACK" position to retract the fork. The lower cylinder port, next to the head, will be under pressure.
2. Remove the hose from the upper port fitting on the cylinder being tested. This fitting is on the return side with the cylinder in this position.
3. Place the free end of the hose in a suitable oil container or bucket to catch feed-back oil from the main reservoir, which is higher than the rest of the system.
4. Move the fork control lever to the DUMP position to apply hydraulic pressure to the cylinder at full system pressure. Check the oil flow at the open fitting.
5. Install the hose after testing, and repeat the procedure on the opposite cylinder.

LIFT CYLINDERS

1. Move the lift arm control lever to the RAISE position to extend the lift cylinders to full stall position. With the lift arms raised to the highest position, block them up carefully in the interest of safety. The rear port, next to the base of the cylinder, will be under pressure.
2. Remove the hose from the front port fitting on the cylinder being tested. This fitting is on the return side with the cylinder in this position, and not under any pressure. This will NOT affect holding position of the lift cylinders.
3. Place the free end of the hose in a suitable oil container or bucket to catch feed-back oil from the main reservoir.
4. Move lift arm control lever to the FLOAT position to apply hydraulic pressure to the cylinder at full system pressure. Check the oil flow at the open fitting.
5. Install the hose after testing and repeat the procedure on the opposite cylinder.

LIFT CYLINDER OVERHAUL

Do not disassemble either cylinder further than necessary to correct a malfunction. During disassembly special attention should be given to identification of parts for proper reassembly.

Cleanliness is of the utmost importance. Place all disassembled parts on a clean, lint-free surface.

Lift cylinder repair kit, Part No.6955191

of fork tines flat on the ground.

NOTE: Each time a cylinder is rebuilt, we recommend that the hydraulic oil be changed. We further recommend the cylinders be rebuilt in pairs.

REMOVING LIFT CYLINDER FROM MACHINE

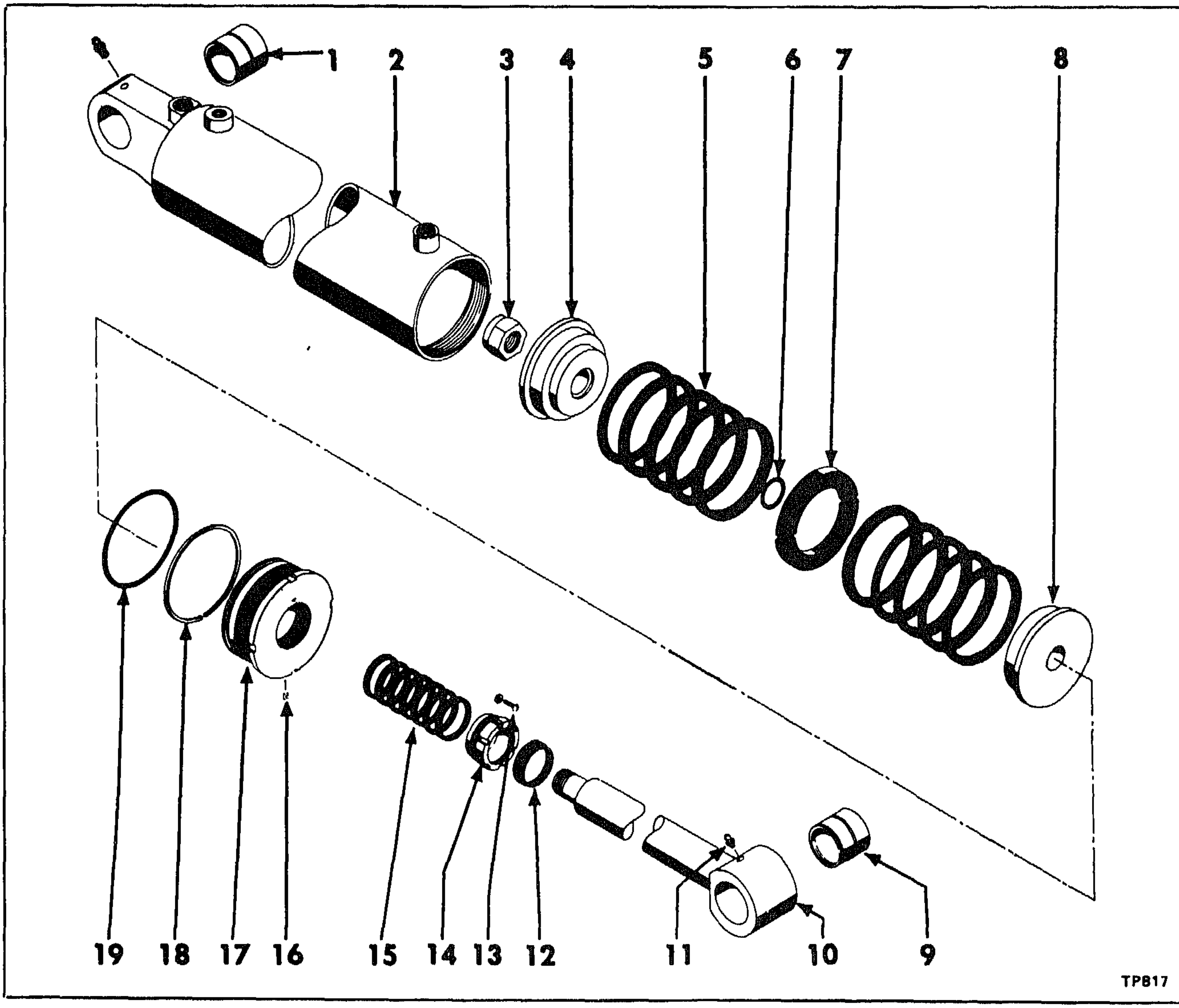
Refer to Lift Arm and Linkage illustration for identification of parts.

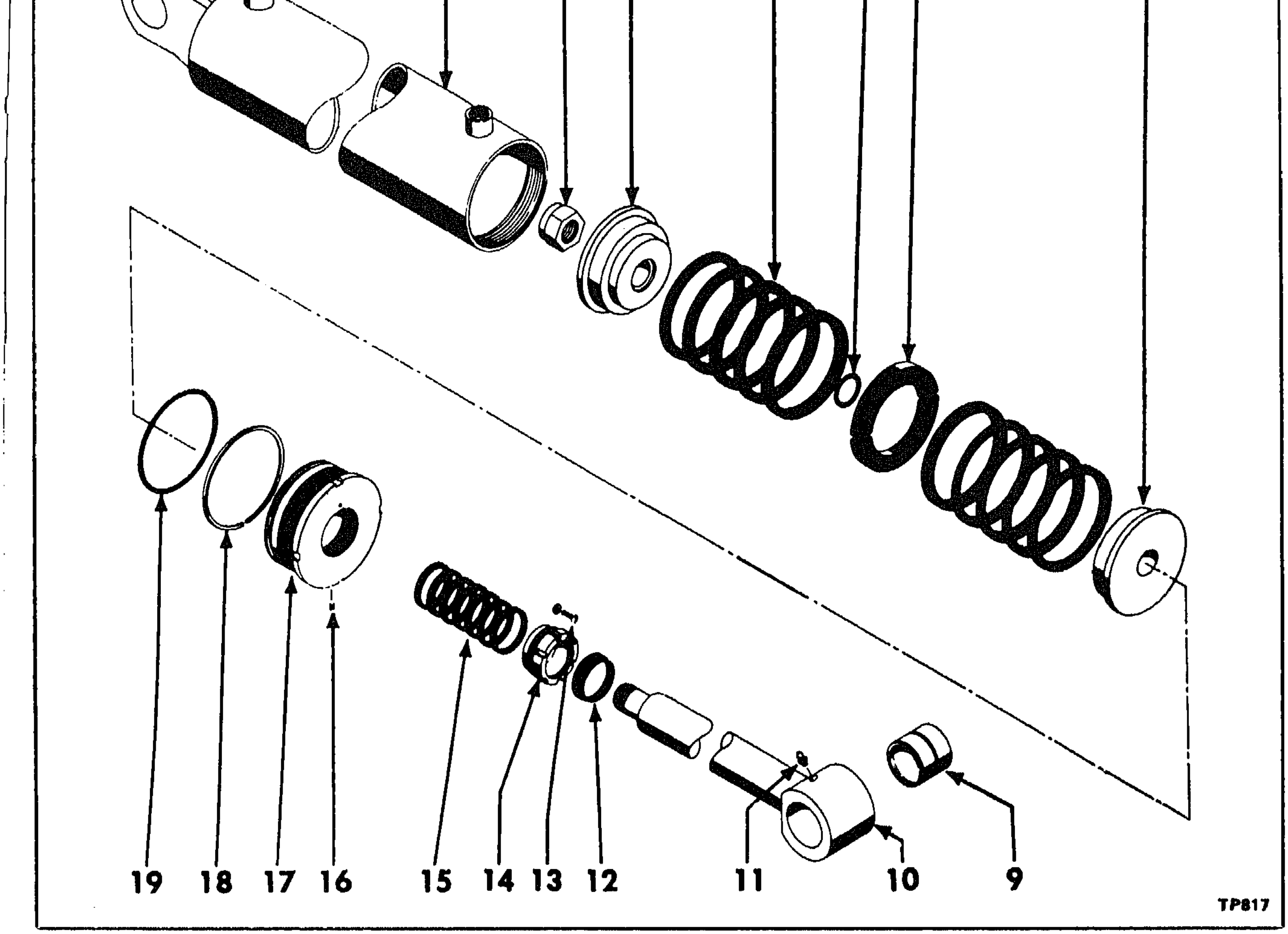
result in damage to the cylinder or injury to persons working on the machine.

Remove the bolts and lockwashers holding the keylock (38); remove the keylock. Remove the bolts and lockwashers holding the lockplate (33); remove the lockplate. Remove the bolt, lockwasher, and nut that secure the lift cylinder to frame pin (34).

Use a suitable pin puller and remove the pin (34) at the cap and the pin (36) at the rod end of the cylinder. Move the cylinder to a suitable location for disassembly.

LIFT CYLINDER

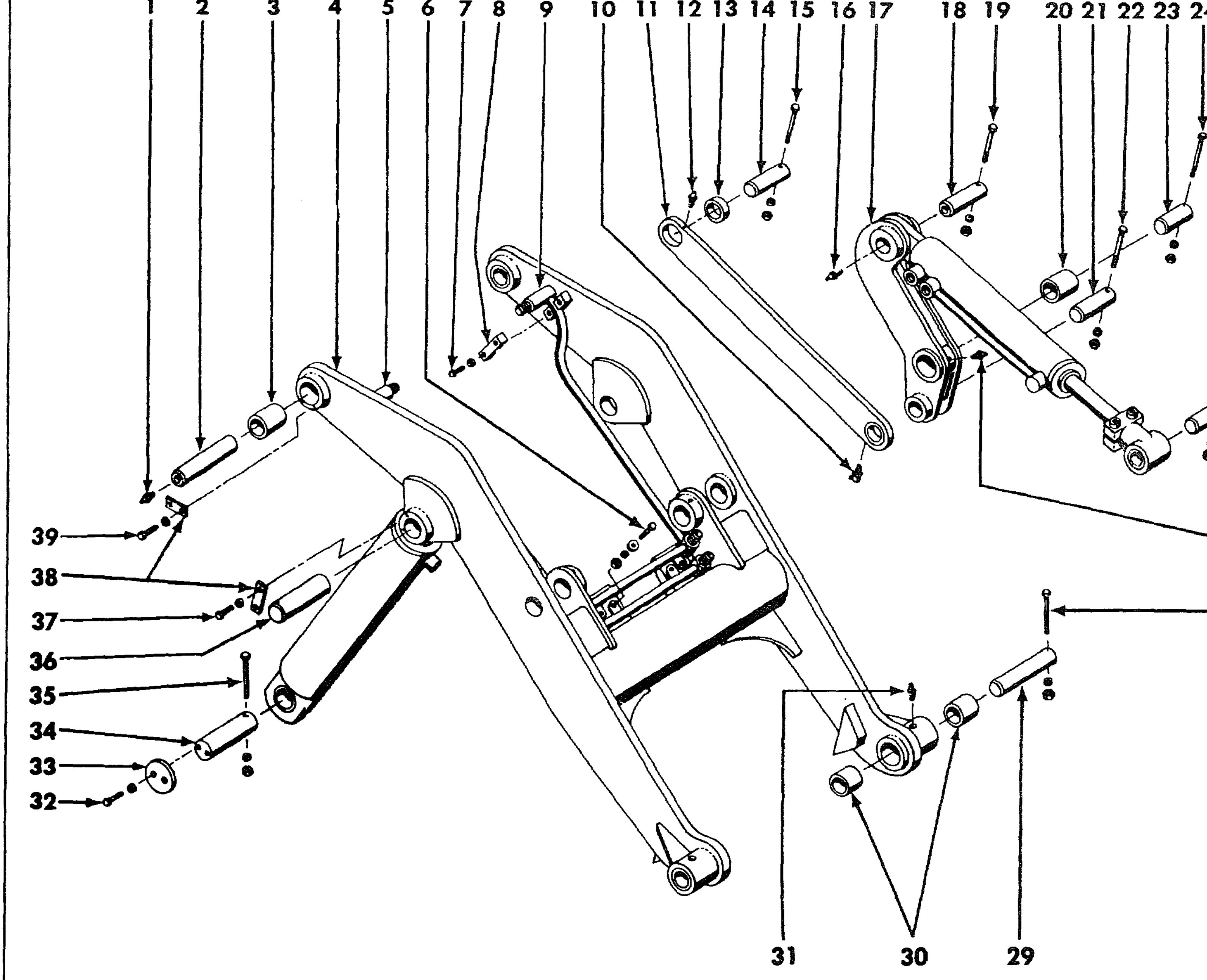




LIFT CYLINDER

Two Cylinders Used per Machine; Quantity Shown is for One.

Item	Part No.	Description	No. Req'd.
A	2059954	Hoist Cylinder Assy. (Incl. Items 1 thru 10 & 12 thru 19)	1
B	6955191	Service Kit (Incl. Items 5, 6, 7, 12, 15, 18 & 19)	1
1	2057179	Bushing	1
2	6700341	Body Assy.	1
3	6700439	Nut, Esna	1
4	6700345	Piston, Half	1
5	6700347	Packing, Piston	2
6	2041374	"O" Ring	1
7	6700348	Bearing, Piston	1
8	6700345	Piston, Half	1
9	2057179	Bushing	1
10	6700342	Rod Assy.	1
11	2057841	Fitting, Grease	2
12	2041153	Wiper	1
13	6700352	Screw	1
13A	2031389	Washer, Lock	1
14	6700343	Nut, Packing	1
15	6700346	Packing, Rod	1
15A	6700440	Washer (N.I.)	2
16	6700378	Set Screw, Socket Hd.	1
17	6700344	Stuffing Box	1
18	6700350	Ring, Back-Up	1
19	2041365	"O" Ring	1



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Item	Part No.	Description	No. Req'd.
1	2030225	Fitting, Grease	2
2	2055508	Pin, Lift Arm Pivot	2
3	2058743	Bushing	2
4	2067990	Lift Arm Assy.	1
5	2058744	Pipe Assy., R.H.	1
6	2031521	Bolt	4
6A	2031619	Nut	4
6B	2032962	Washer, Flat	4
6C	2031393	Washer, Lock	4
7	2031524	Bolt	4
7A	2031393	Washer, Lock	4
8	2068076	Block	2
9	2058751	Pipe Assy., L.H.	1
10	2033249	Fitting, Grease	2
11	2058921	Leveling Arm Assy.	2
12	2030225	Fitting, Grease	2
13	2056415	Bushing	4
14	2058926	Pin, Leveling Arm to Frame	2
15	2031532	Bolt	2
15A	2031619	Nut	2
15B	2031393	Washer, Lock	2
16	2030225	Fitting, Grease	2
17	2058906	Bellcrank Assy.	2
18	2058927	Pin, Bellcrank to Bucket Cylinder	2
19	2031535	Bolt	2
19A	2031619	Nut	2
19B	2031393	Washer, Lock	2
20	2058913	Bushing	2
21	2058926	Pin, Leveling Arm to Bellcrank	2
22	2031532	Bolt	2
22A	2031619	Nut	2
22B	2031393	Washer, Lock	2
23	2058929	Pin, Bellcrank to Lift Arm	2
24	2031535	Bolt	2
24A	2031619	Nut	2
24B	2031393	Washer, Lock	2
25	2031535	Bolt	2
25A	2031619	Nut	2
25B	2031393	Washer, Lock	2
26	2058928	Pin, Fork Cylinder to Fork Frame	2
26A	2030225	Fitting (N.I.)	2
27	2033250	Fitting, Grease	2
28	2031535	Bolt	2
28A	2031619	Nut	2
28B	2031393	Washer, Lock	2
29	2056547	Pin, Lift Arm to Bucket	2
30	2056531	Bushing	4
31	2030225	Fitting, Grease	2
32	2031519	Bolt	2
32A	2031393	Washer, Lock	2
33	2060024	Plate, Lock	2
34	2058942	Pin, Hoist Cylinder Pivot	2
35	2053396	Bolt, Pinlock	2
35A	2031619	Nut	2
35B	2031393	Washer, Lock	2
36	2058923	Pin, Hoist Cylinder to Lift Arm	2
37	2031517	Bolt	4
37A	2031393	Washer, Lock	4
38	2042606	Keylock	4
39	2031517	Bolt	4
39A	2031393	Washer, Lock	4

(N.I.) Not Illustrated

LIFT CYLINDER DISASSEMBLY

Refer to Lift Cylinder illustration for identification of parts.

During disassembly, clean all parts except sealing elements in clean mineral oil solvent. After drying thoroughly, lay parts on a clean, lint-free surface for inspection. Never use an air hose on or near the exposed parts because of the presence of water and dirt in the system.

Remove set screw (13) and lockwasher (13A).

Using a spanner wrench, unscrew packing nut (14) and remove it from cylinder tube.

Pull rod assembly to its full extension then remove set screw (16). Use a spanner wrench to unscrew and remove stuffing box (17) from the cylinder. During and after this operation, the rod assembly must be held by hand in the center of the body assembly (2).This is to protect the inner wall of the body assembly from being scratched by the piston halves (4) and (8).

Pull the rod assembly and piston assembly from body by hand, being very careful not to scratch the inner walls. Keep rod in the center diameter of the body assembly.

Place the eye of the rod assembly in a machinist's vise, using protective jaws. Do not damage the eye.

Remove nut (3), piston halves (4) and (8) with piston packings (5), piston bearing (7), and "O" ring (6) from rod assembly. Remove rod packing (15), "O" ring (19), and backup ring (18) from stuffing box. Remove packing nut (14) from rod assembly. Use a hook scriber or suitable tool to remove wiper ring (12) from packing nut.

LIFT CYLINDER INSPECTION

Discard all sealing elements and replace with new.

Check each disassembled part for wear, cracks or pitting that would render them unfit for further use. Pay particular attention to the inner walls of the body assembly and the surface of the rod assembly.

Inspect the mounting pins for wear or scoring; replace if necessary.

Inspect the bushings (1) and (9) in the mounting bores; replace if worn, scored, or loose.

LIFT CYLINDER REASSEMBLY

Coat each part with a film of clean hydraulic oil to facilitate reassembly. Coat all sealing elements with liberal amounts of petroleum jelly prior to assembly. Slide the wiper (12), packing nut (14) and packing (15) on the rod assembly.

Replace backup ring (18) and "O" ring (19) and set screw (16) on stuffing box (24). Install the assembled stuffing box on the rod assembly.

Place flat mounting end of rod assembly (10) in vise and install piston half (8) on the rod until it bottoms. Install "O" ring (6) in the piston half recess.

Place one set of packing (5) snugly in piston half.

Place one set of packing (5) snugly in the piston half (4) and install the piston on the rod assembly.

Install the halves of the piston bearing (7) between the piston halves (4) and (8). Turn nut (3) on the rod assembly and tighten to 30 lb. ft. torque.

With the body assembly (2) held securely, place the piston and rod assembly in the center of the body assembly diameter and push the piston and rod firmly in, being careful not to scratch the inner walls of the body assembly. Insert the piston just far enough inside the body assembly so that the thread of the stuffing box (17) engages the body assembly thread.

Now that the piston is in the body assembly, oil the inner body assembly walls again and install the stuffing box (17), being careful not to unseat the "O" ring (19) or backup ring (18). Very carefully push the piston in until it bottoms on the base of the cylinder. Use a spanner wrench to tighten stuffing box and set screw (16) securely.

Insert packing (15) in the stuffing box. Work each ring down smoothly without distortion or damage. Be very careful; a damaged ring must be discarded and a new set purchased. Use a flat tool to work in the new rings, taking care not to cut the rings or damage the stuffing box threads.

Install wiper (12) in packing nut (14); oil rod assembly once more and install packing nut in the stuffing box. Draw up snugly with spanner wrench. A properly adjusted nut will allow a light film of oil to remain on the rod assembly as it is drawn out of the cylinder.

Replace lockwasher (13A) and set screw (13).

for part identification. Use a hoist or block the cylinder in position with the mounting bores aligned with the mountings on the lift arm and frame.

Install the pin (36) in the rod end bore. Position the lock (38) in the slot of the pin; secure to the lift arm with two bolts and lockwashers.

Install the pin (34) in the cap and bore. Align the hole in the pin with the hole in the frame mounting; secure with a bolt, lockwasher and nut. Replace lockplate (33), two bolts and lockwasher. Connect the hydraulic lines to the cylinder.

NOTE: We recommend that cylinders be replaced or rebuilt in pairs.

Drain the hydraulic oil and refill the system whenever a cylinder is replaced. Lubricate the mounting bushings; refer to the Lubrication section.

FORK CYLINDER OVERHAUL

Do not disassemble either cylinder further than necessary to correct a malfunction. During disassembly special attention should be given to identification of parts for proper reassembly.

Cleanliness is of the utmost importance. Place all disassembled parts on a clean, lint-free surface.

Fork Cylinder Repair Kit, Trojan Part No. 6955190 contains all the sealing elements; each item may be identified by checking the Fork Cylinder illustration.

Before attempting to remove either cylinder, the machine must be on level terrain with the complete bottom of fork tines flat on the ground. Measure the distance from the center of the pin in the head to the center of the pin in the cylinder tube base. This is important because the head must be assembled on the piston rod in the same location as it was before disassembly.

NOTE: Each time a cylinder is rebuilt, we recommend that the hydraulic oil be changed. We further recommend that cylinders be rebuilt in pairs.

REMOVING FORK CYLINDER FROM MACHINE

Refer to the Lift Arm and Linkage illustration for identification of parts.

result in damage to the cylinder or injury to perso working on the machine.

Remove the bolt, lockwasher, and nut securing the p (26) to the boss on the bucket. Use a suitable pin pull and remove the pin.

Remove the bolt, lockwasher, and nut securing the p (18) to the bellcrank assembly (17). Use a suitable p puller to remove the pin (18). Move the cylinder to appropriate location for disassembly.

FORK CYLINDER DISASSEMBLY

Refer to Fork Cylinder illustration for identificati of parts.

During disassembly, clean all parts except seali elements in clean mineral oil solvent. After dryi thoroughly, lay parts on a clean, lint-free surface f inspection. Never use an air hose on or near the expos parts because of the presence of water and dirt in t system.

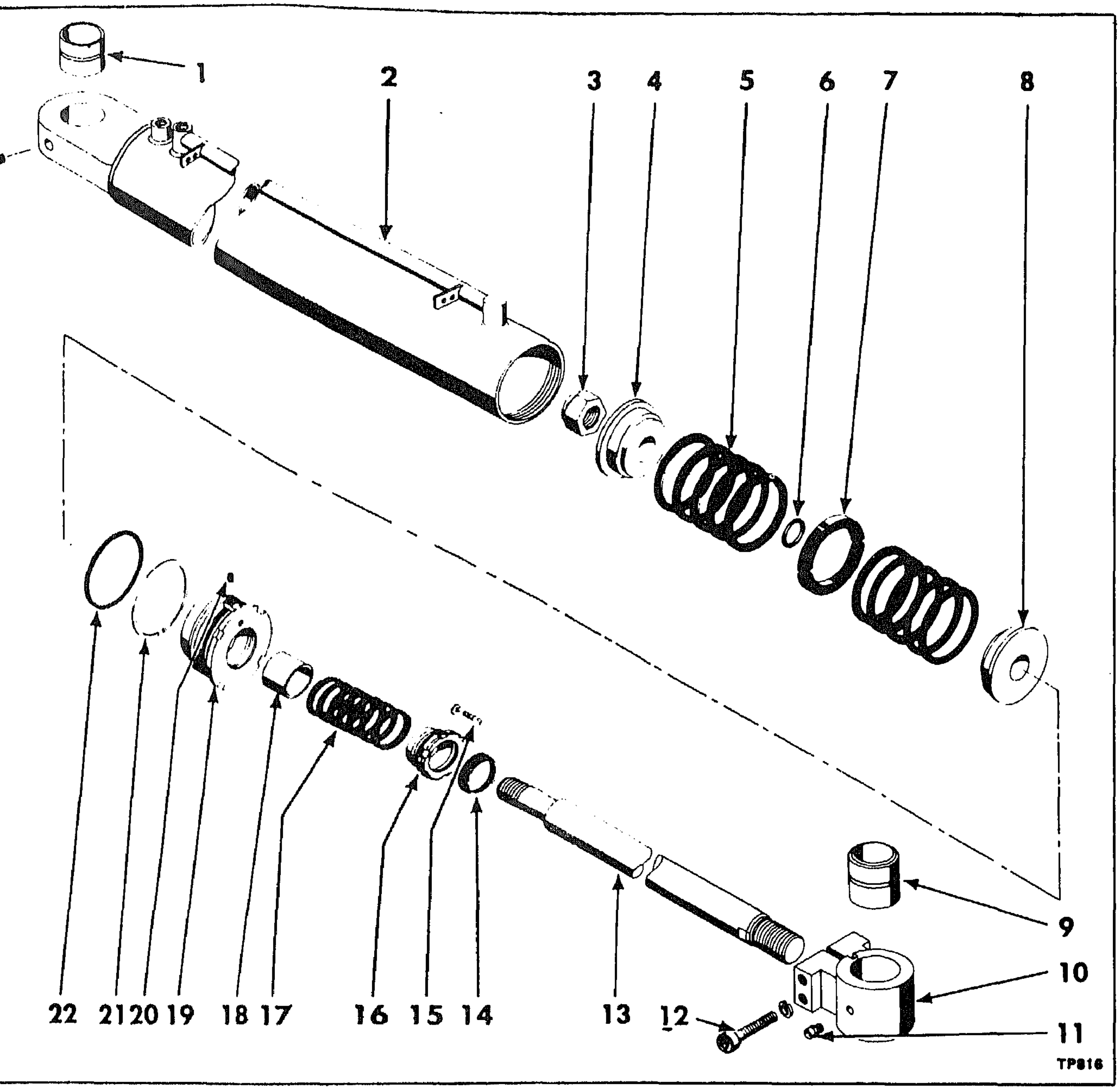
Loosen locking bolts (12). Remove cylinder head (1 from piston rod (13).

Remove set screw (15) and lockwasher (20).

Using a spanner wrench, unscrew packing nut (16) a remove from piston rod. Use a hood scriber or suital tool for removal of wiper ring (14).

Pull piston rod (13) to its full extension; remove screw (20). Use a spanner wrench to unscrew and move stuffing box (19) from the cylinder. During a after this operation the piston rod must be held hand, in the center of the body assembly (2), to p tect the inner walls of the body assembly from bei scratched by the assembled piston (4) and (8). Remo rod packing (17), "O" ring (22), and backup ri (21) from the stuffing box.

Pull the piston rod and piston assembly from assembly by hand, being very careful not to sc inner walls. Keep rod in the center diameter of assembly. Place the flat at the thread end of rod in a machinist's vise, using protective jaws damage the threads.



ove nut (3), piston halves (4) and (8) with piston ing (5), "O" ring (6), and piston bearing (7) from piston rod (13).

K CYLINDER INSPECTION

ard all sealing elements and replace with new. Wash arts in mineral oil solvent. Dry thoroughly.

k each disassembled part for wear, cracks, or pit- that would render them unfit for further use. Pay cular attention to the inner walls of the body assem- nd the surface of the piston rod.

ect the mounting pins for wear or scoring; replace ecessary.

Inspect the bushings (9) in the head bore; replace if worn, scored, or loose.

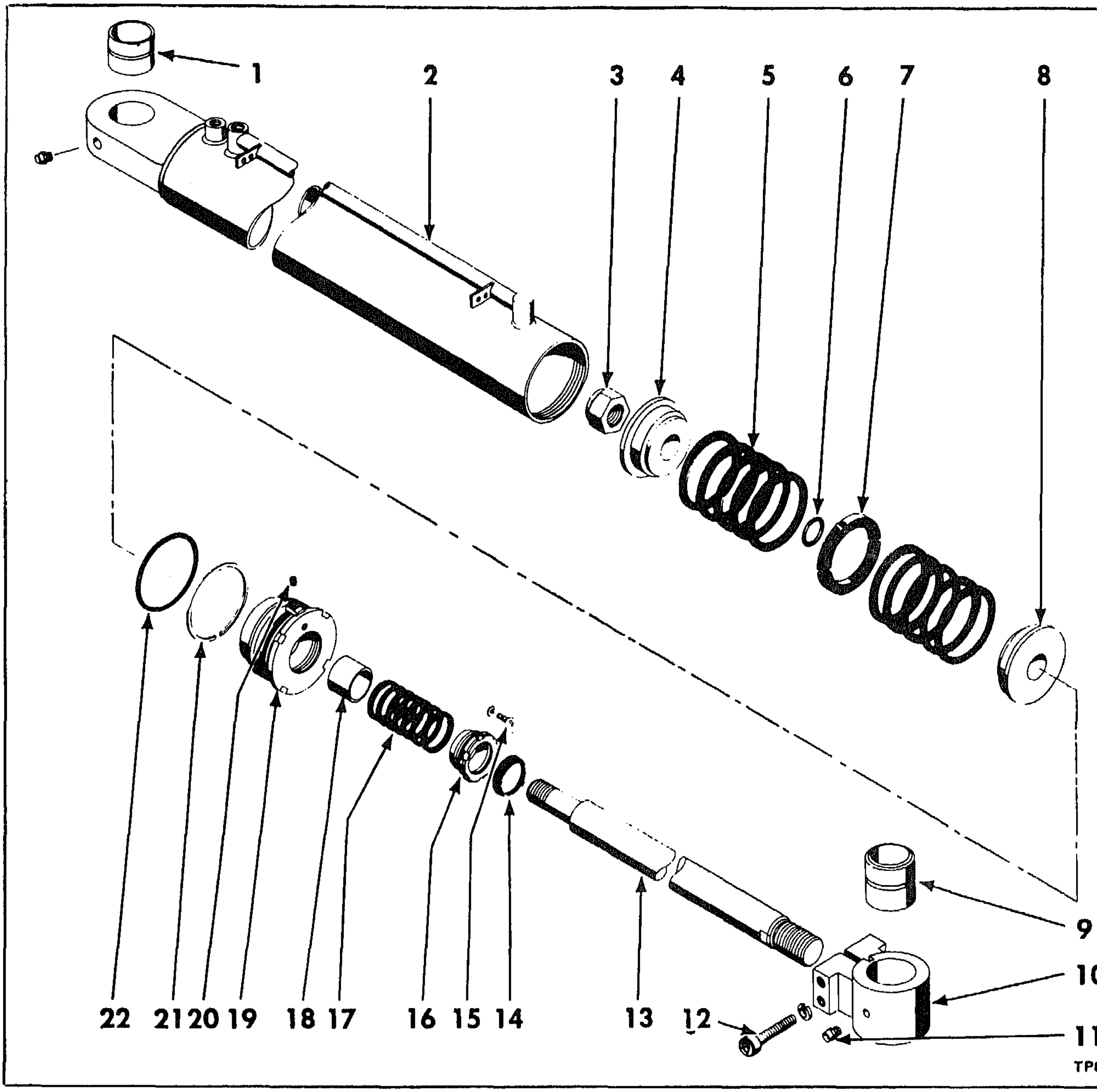
Inspect the bushing (18) in the stuffing box (19); replace if worn, scored, or loose.

FORK CYLINDER REASSEMBLY

Coat each part with a film of clean hydraulic oil to facilitate reassembly. Prior to assembly, liberally coat all sealing elements with petroleum jelly.

Replace backup ring (21), "O" ring (22), and set screw (20) on stuffing box (19). Lay aside.

Place piston rod (13) in vise at flat and install piston half (8) on the rod against the shoulder. Install "O" ring (6) in the piston half.



FORK CYLINDER

Two Cylinders Used per Machine; Quantity Shown is for One.

Item	Part No.	Description	No. Req'd.
A	2058432	Fork Cylinder Assy. (Incl. Items 1 thru 8 & 13 thru 22)	1
B	6955190	Service Kit (Incl. Items 5, 6, 7, 14, 17, 21 & 22)	1
1	2056169	Bushing	1
2	6700504	Body Assy.	1
3	2040082	Nut, Esna	1
4	6700340	Piston, Half	1
5	6700338	Packing, Piston	2
6	2040085	"O" Ring	1
7	6700339	Bearing, Piston	1
8	6700340	Piston, Half	1
9	2045616	Bushing	1
10	2057871	Ram Head	1

Item	Part No.	Description	No. Re
11	2057841	Fitting, Grease	2
12	2037889	Bolt	2
12A	2032802	Washer, Lock	2
13	6700336	Rod	1
14	2040092	Wiper	1
15	6700352	Screw	1
15A	2031389	Washer, Lock	1
16	2040091	Nut, Packing	1
17	6700258	Packing, Rod	1
18	6700143	Bushing	1
19	6700337	Stuffing Box	1
20	6700378	Screw, Soc. Hd. Set	1
21	2040112	Ring, Back-Up	1
22	2040111	"O" Ring	1

Place one set of packing (5) snugly on the piston half (8). Place one set of packing (5) snugly on the piston half (4) and install piston on piston rod.

Install the halves of the piston bearing (7) between the piston halves (4) and (8).

Turn nut (3) on the piston rod and tighten to 30 lb. ft. torque.

With the body assembly (2) held securely, place the piston and rod in the center of its diameter and push the rod firmly in, being careful not to scratch the inner walls of the body assembly. Insert the piston just far enough inside the body assembly so that the stuffing box (19) may engage its thread and be screwed in.
Now that the piston is in the body assembly, oil the inner body assembly walls again and install the stuffing box (19), being careful not to unseat the "O" ring (22) or backup ring (21). Very carefully push the piston in until it bottoms on the base of the cylinder. Use a spanner wrench to tighten stuffing box and set screw (20) securely.

Insert packing (17) in the stuffing box. Work each ring down smoothly, without distortion or damage. Be very careful; a damaged ring must be discarded and a new set purchased. Use a flat tool to work in the new rings, being careful not to cut the rings or damage the stuffing box threads.

Install wiper ring (14) in packing nut (16), oil piston rod again and install packing nut in the stuffing box. Draw up packing nut snugly with spanner wrench. A properly adjusted nut will allow a light film of oil remain on the piston rod as it is drawn out of th cylinder.

Replace lockwasher (15A), and set screw (15).

Turn head (10) on piston rod to the same location had before removal. Hold piston rod with wrench o flat if necessary. Draw bolts (12) down evenly, torqu to 250 lb. ft. torque dry thread.

INSTALLING FORK CYLINDER ON THE MACHINE

Refer to the Lift Arm and Linkage illustration for part identification.

Use a hoist or block the cylinder in position, alignin the mounting bores with the mountings on the lift ar and fork carriage assembly.

Install the pin (18) in the base bore. Secure to the be crank assembly (17) with a bolt, lockwasher, and nu Install the pin (26) in the cap end bore. Align the ho in the pin with the hole in the bucket boss; secure wi a bolt, lockwasher, and nut.

Connect the hydraulic lines to the cylinder.

NOTE: We recommend that cylinders be replaced rebuilt in pairs.

Drain the hydraulic oil and refill the system whenev a cylinder is replaced. Lubricate the mounting bushin and pin; refer to the Lubrication section.

ADJUSTING MAIN RELIEF VALVE

Refer to Fig. 16 for identification of parts.

Install a 0-3000 psi pressure gauge in the ¼-inch port just to the right of the name plate on the main control valve.

Remove acorn nut and loosen jam nut on main relief valve.

Start the engine and run at maximum speed. Stall system to obtain maximum pressure reading on gauge.

Check the gauge pressure reading. If the pressure reading does not stabilize at 1650 psi, turn the adjusting screw to obtain this pressure. Turn the screw in to increase pressure, out to decrease pressure.

When pressure stabilizes at 1650 psi, hold the adjusting screw and tighten the jam nut.

Install the acorn nut.

Remove the pressure gauge and line.

OVERHAUL OF MAIN RELIEF VALVE

Refer to Fig. 17 for identification of parts.

If adjustment of the main relief valve does not provide a stabilized pressure at 1650 psi and the trouble is suspected to be in the control valve, overhaul the relief valve. Wire brush, wipe, and blow clean with an air hose around the relief section. Overhaul the relief valve as follows:

DISASSEMBLY

Remove the acorn nut, jam nut, two washers, and adjusting screw.

Remove poppet and spring from plug bore.

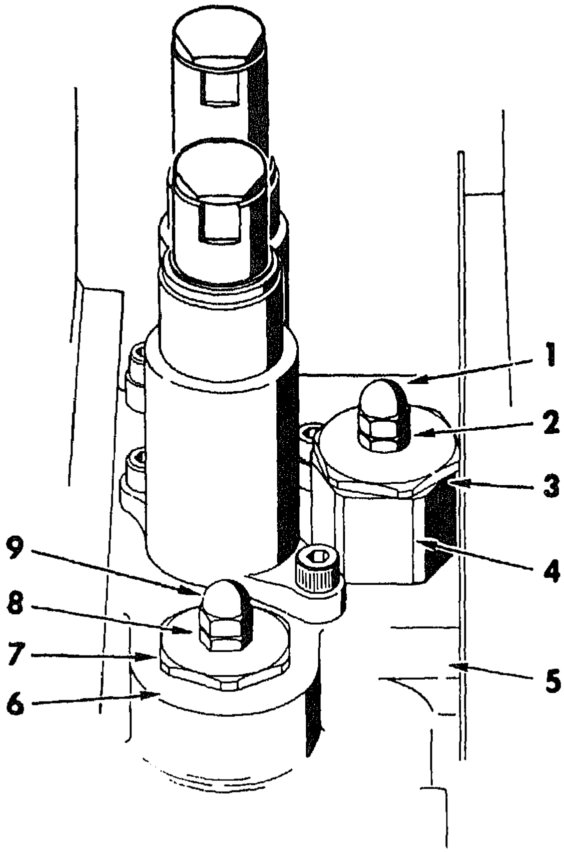
Remove the plug. Remove "O" ring, backup ring, and "O" ring from the outside of the plug.

Remove spring and piston from relief bore.

Remove the main poppet. Remove the "O" ring and backup ring from the main poppet.

CLEANING AND INSPECTION

Clean all parts in a clean mineral oil solvent before inspection. Because of fire hazards and insurance regulations, we do not recommend gasoline or any other volatile solvent, such as naphtha, benzene, etc. Less flammable fluids such as kerosene or mineral spirits should be used. Do not use caustic solution. After drying thoroughly with clean cloth, lay parts on a clean, lint-free surface for inspection. Never use an air hose on or near the exposed parts because of the presence of water and dirt in the air system.

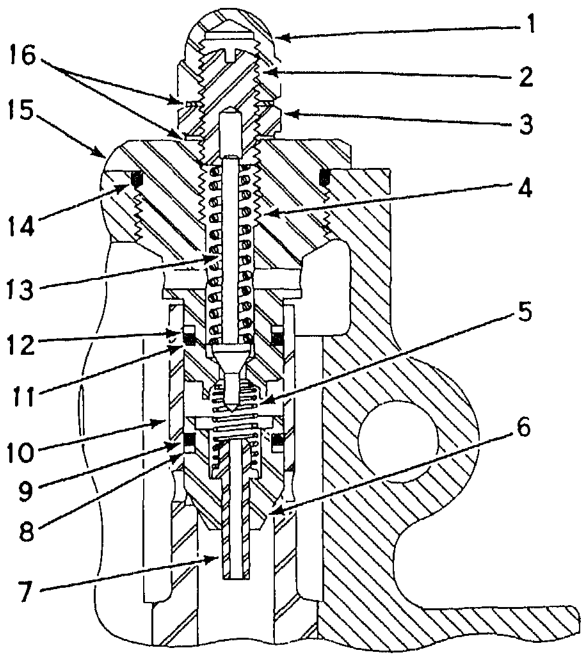


1. Acorn Nut
2. Jam Nut
3. Plug
4. Cylinder Relief Valve
5. Hydraulic Control Valve
6. Main Relief Valve Cap
7. Plug
8. Jam Nut
9. Acorn Nut

Fig. 16. Control Valve, Main Relief Valve, and Cylinder Relief Valve Adjustment

Inspect the ground seating surface of the main poppet for nicks or excessive wear. Insert poppet without "O" ring or backup ring fully into the sleeve and test for fit. The poppet should fit snugly but without binding through a complete revolution. Inspect the ground seating surface of the pilot poppet for nicks or excessive wear. The pilot seating edge of the sleeve should be sharp and free of nicks. Inspect the sleeve bore for scores or roughness. Check the small connecting holes and the cross hole for dirt or obstructions. Shine a bright light into the pilot end of the sleeve and inspect the pilot seat. It should be clean and sharp. Discard any parts found to be faulty.

Replace all "O" rings, backup rings, and springs at each overhaul.



1. Acorn nut
2. Adjusting screw
3. Jam nut
4. Spring
5. Spring
6. Poppet
7. Piston
8. Backup ring
9. "O" ring
10. Sleeve
11. "O" ring
12. Backup ring
13. Poppet
14. "O" ring
15. Plug
16. Washer

Fig. 17. Main Relief Valve, Sectional View

REASSEMBLY

Position an "O" ring and backup ring in the oute groove of the main poppet with the backup ring in th side of the groove closest to the tapered end. Slid the main poppet in the valve sleeve until it seats. Insta the piston with the long end in the hole of the mai poppet. Install the spring around the piston top.

Install an "O" ring in the large diameter groove of th plug and an "O" ring and backup ring in the small groove. Place the backup ring in the groove toward th center of the plug. Install the assembled plug in th valve, catching the spring in the central counterbo and seating the plug in the sleeve.

Install the pilot poppet in the plug with the short ste fitting through the bore of the plug into the spring the main poppet. Install the spring over the long ste of the pilot poppet.

Install the adjusting screw loosely and screw the ja nut loosely on the adjusting screw.

Set the main relief valve adjustment. Install the aco nut.

ADJUSTING FORK CIRCUIT RELIEF VALVE

Refer to Fig. 18 for identification of parts.

Install a 0-2000 psi pressure gauge in the ¼-inch po in the main control valve just to the right of the nan plate.

Remove acorn nut and loosen jam nut from fo circuit relief valve.

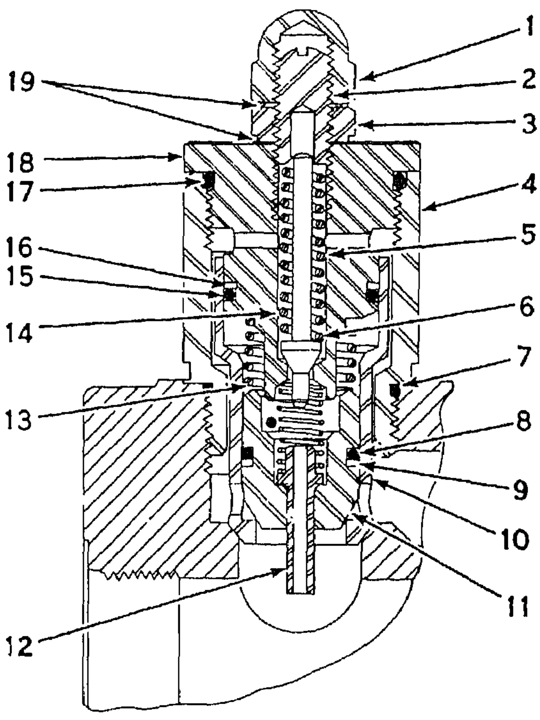
Start the engine and run at maximum speed. Pull th fork control lever back toward the TIP BACK pos tion until the fork cylinders are fully retracted, an read the pressure gauge.

If the pressure does not stabilize at 1100 psi, turn th adjusting screw. Turn the screw in to increase pressu out to decrease pressure.

When pressure stabilizes at 1100 psi, hold the adjusti screw and tighten the jam nut.

Install the acorn nut.

Remove the pressure gauge and line.



1. Acorn nut	11. Poppet
2. Adjusting screw	12. Piston
3. Jam nut	13. Spring
4. Cap	14. Spring
5. Spring	15. "O" ring
6. Poppet	16. Backup ring
7. "O" ring	17. "O" ring
8. "O" ring	18. Plug
9. Backup ring	19. Washer
10. Poppet	

Fig. 18. Fork Circuit Relief Valve, Sectional View

OVERHAUL OF FORK CIRCUIT RELIEF VALVE

Refer to Fig. 18 for identification of parts.

If adjustment of the fork circuit relief valve does not provide a stabilized pressure at 1100 psi and the trouble is suspected to be in the control valve, overhaul the fork circuit relief valve. Wire brush and wipe clean all the areas around the control valve openings. Blow all dirt and scale from the area with an air hose.

Overhaul the fork circuit relief valve as follows:

DISASSEMBLY

Remove the acorn nut, jam nut, two washers, and the adjusting screw.

Remove spring and poppet from plug bore.

Turn the cap out of the control valve body; remove the "O" ring.

Place the cap in a vise with protective jaws and screw the plug out of the cap. Remove the "O" ring from the plug outside diameter. The remainder of the valve parts will come out with the plug. Take care not to score or scratch the surface of the poppet on the threads of the cap while removing it.

Remove the two assembled poppets from the plug. Remove the "O" ring and backup ring from the plug. Remove the large spring, small spring, piston, and inner poppet from the outer poppet. Remove the "O" rings and backup rings.

CLEANING AND INSPECTION

Clean all parts in a clean mineral oil solvent before inspection. Because of fire hazards and insurance regulations, we do not recommend gasoline or any other volatile solvent, such as naphtha, benzene, etc. Less flammable fluids such as kerosene or mineral spirits should be used. Do not use caustic solution. After drying thoroughly with clean cloth, lay parts on clean, lint-free surface for inspection. Never use an air hose on or near the exposed parts because of the presence of water and dirt in the air system.

Inspect the ground seating surface of the poppets for nicks or excessive wear. Insert poppets without "O" rings or backup rings and test for fit. The poppets should fit snugly but without binding through a complete revolution. Inspect the ground seating surface of the pilot poppet for nicks or excessive wear. The pilot seating edge of the plug should be sharp and free of nicks. Inspect the plug bore for scores or roughness. Check the small connecting holes and the cross hole for dirt or obstructions. Shine a bright light into the pilot end of the large poppet and inspect the seat. It should be clean and sharp. Discard any parts found to be faulty.

Replace all "O" rings, backup rings, and springs at each overhaul.

REASSEMBLY

Install the "O" ring and backup ring in the groove in the outer diameter of the main poppet with the backup ring toward the tapered side of the poppet.

Slide the assembled main poppet in the sleeve poppet until it seats. Install the piston in the bore of the poppet with the long stem through the bore. Install the fine spring over the short stem of the piston in the counterbore of the main poppet.

Install the "O" ring in the groove in the outer diameter of the cap; install the cap in the valve port and tighten securely. Slide the assembled main poppet and sleeve poppet into the cap, taking care that the surface of the sleeve poppet is not damaged as it passes the threads of the cap.

Install an "O" ring in the large diameter groove of the plug and an "O" ring and backup ring in the small diameter groove. Install the backup ring toward the center of the plug. Install the large spring over the end of the plug. Install the partially assembled plug in the cap; tighten securely. Make sure the fine spring in the main poppet enters the counterbore of the plug.

Install the pilot poppet in the plug with the short end of the poppet through the bore of the plug and seating in the bore. Install the spring around the long end of the pilot poppet.

Loosely install the adjusting screw, jam nut, and two washers.

Adjust the pressure setting of the fork circuit relief valve. Install the acorn nut.

ADJUSTING HOIST CIRCUIT RELIEF VALVE

Install a 3000 psi pressure gauge in the ¼-inch port in the main control valve just to the right of the name plate.

Remove acorn nut and loosen jam nut from main relief valve. See Fig. 17.

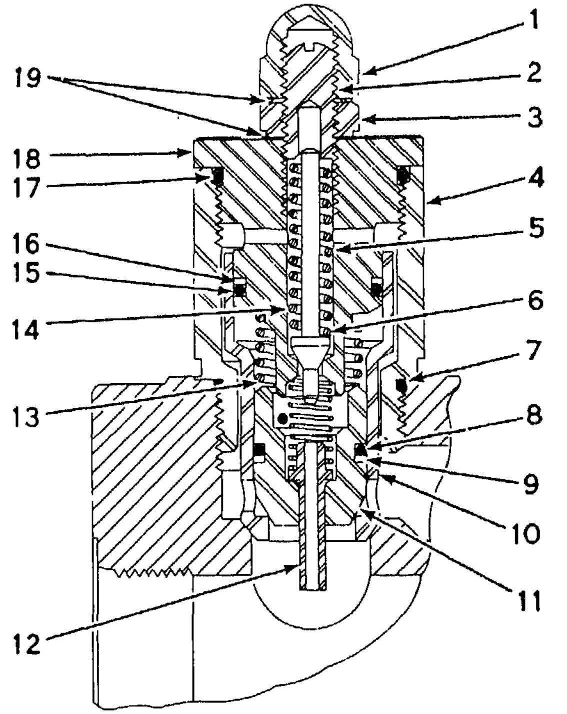
Start and run the engine at maximum speed. With the lift arms down move the fork to the extreme TIP BACK position.

Adjust the main relief valve to 2000 psi reading on the gauge. Turn the screw in to increase the pressure, out to decrease the pressure. Tighten the jam nut, but leave the acorn nut and washer off the main relief valve.

Remove the acorn nut and loosen jam nut on the hoist relief valve. Run the engine at maximum speed. Lift the fork to the extreme raised position and hold. Adjust hoist circuit relief valve to 1900 psi reading on the gauge. Tighten the jam nut. Turn the screw in to increase pressure, out to decrease pressure. Replace washer and acorn nut on the hoist relief valve.

Lower fork enough to clear the ground.

Run the engine at maximum speed. Move the fork to the extreme TIP BACK position and hold. Readjust main relief valve to 1800 psi reading on the gauge. Tighten the jam nut and replace washer and acorn nut on main relief valve.



1. Acorn nut
2. Adjusting screw
3. Jam nut
4. Cap
5. Spring
6. Poppet
7. "O" ring
8. "O" ring
9. Backup ring
10. Poppet
11. Poppet
12. Piston
13. Spring
14. Spring
15. "O" ring
16. Backup ring
17. "O" ring
18. Plug
19. Washer

Fig. 20. Hoist Circuit Relief Valve, Sectional View

Install the acorn nut on the main relief valve.

Remove the pressure gauge and line from the port in th main control valve.

OVERHAUL OF HOIST CIRCUIT RELIEF VALVE

Refer to Fig. 20 for identification of parts.

If adjustment of the hoist circuit relief valve does nc provide a stabilized pressure at 1900 psi and the troubl is suspected to be in the control valve, overhaul th hoist circuit relief valve. Wire brush and wipe clea all the areas around the control valve openings. Blo all dirt and scale from the area with an air hose.

Overhaul the hoist circuit relief valve by following ir structions in the overhaul of fork circuit relief valv section. Fork and hoist valves are identical.

levers separately, until about half the stroke of each cylinder is reached. Return levers to neutral position and repeat. There should be no cylinder drop when levers are operated again.

Next, with cylinders (lift and fork) partially extended and control levers in neutral position, turn off engine and carefully move each control lever, separately to RAISE (lift arm control lever) or TILT BACK (fork control lever) position. Lift arms and fork should remain stationary. If they do not remain stationary, the check valve in the lift or fork hydraulic circuit (or both) is leaking and should be repaired.

Another more precise way to check the load check valves is to install an accurate pressure gauge to the cylinder port (lift arm or fork) that is controlled by the spool or plunger being tested.

Start engine; actuate the plunger until full relief valve pressure is indicated by the gauge. With full relief pressure (1650 psi or 1100 psi, fork cylinders extended only) in the cylinder port and the plunger in operating position, stop the engine and check the rate of pressure drop at the cylinder port.

It must be noted that this pressure drop reflects not only the leakage past the load check valve, but also at the cylinder packing and around the plunger.

The valve spools or plungers can be tested in a similar manner with full relief pressure in the cylinder port, controlled by the plunger being tested; return plunger to neutral position. The rate at which the pressure drops is an indication of leakage past the plunger. The rate of drift of the cylinder is also an indication.

In performing these tests, it is assumed that the cylinder packings have been recently replaced or are in good condition.

OVERHAUL OF CHECK VALVES

One check valve is used for each spool. To remove parts for replacement or cleaning, refer to Fig. 21 and the procedure that follows.

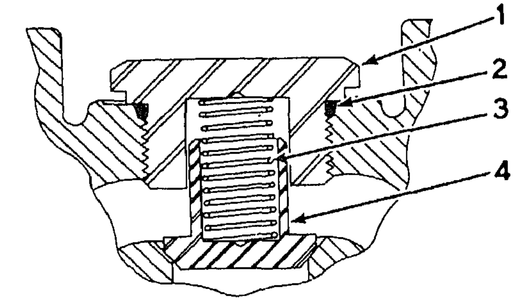
The check valves are of the poppet type and are spring loaded. They normally require very little service.

The check valve poppet and spring are retained by the check valve plug and may be removed by unscrewing the plug. Check valve malfunctioning is usually the result of foreign matter lodging between the seat and poppet. While disassembled, examine seat for dirt or metal particles, and check seating surfaces for nicks or scratches. Minor scratches may be removed by lapping poppet in body seat, using a fine grain lapping compound. Lap seat sufficiently to remove defects. Thoroughly wash valve body to remove all traces of lapping compound. Poppet must fit loosely in plug.

body bores.

To install, slide poppet in body bore until fully seated.

Next, insert spring. Place new "O" ring on plug and install until plug bottoms; tighten.



1. Plug
2. "O" ring
3. Spring
4. Poppet

Fig. 21. Check Valve, Sectional View

VOID CONTROL VALVE

Two void control valves are located opposite the cylinder relief valve at the bottom of the control valve. To remove parts for replacement or cleaning, refer to Fig. 22 and the procedure that follows:

The poppet of the void control valve is hydraulically balanced. When sufficient pressure is exerted against the shoulder of the poppet to overcome the spring pressure, the poppet is forced off the seat. The valve normally requires very little service.

Remove the plug, spring, and assembled poppet from the control valve port.

Remove the stop nut from the poppet. Remove the spacer from the poppet. Remove the "O" rings and backup ring from the spacer. Remove the "O" ring from the internal groove of the stop nut.

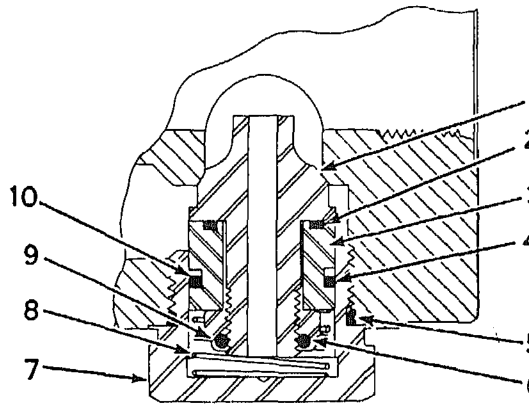
Poppet valve malfunction is usually the result of foreign matter lodging between the seat and the poppet. Examine the seat for dirt or metal particles, and check seating surfaces for nicks or scratches. Minor scratches may be removed by lapping poppet in body seat, using a fine grain lapping compound. Lap seat sufficiently to remove defects. Thoroughly wash valve body to remove all traces of lapping compound.

Replace spring if it is broken, weak, or distorted. Replace "O" rings when reassembling.

Install a new "O" ring in the internal groove of the stop nut. Install an "O" ring and backup ring in the outside diameter groove of the spacer. Make sure the backup ring is toward the bottom of the spacer (end with "O" ring groove). Install an "O" ring in the groove at the bottom of the spacer.

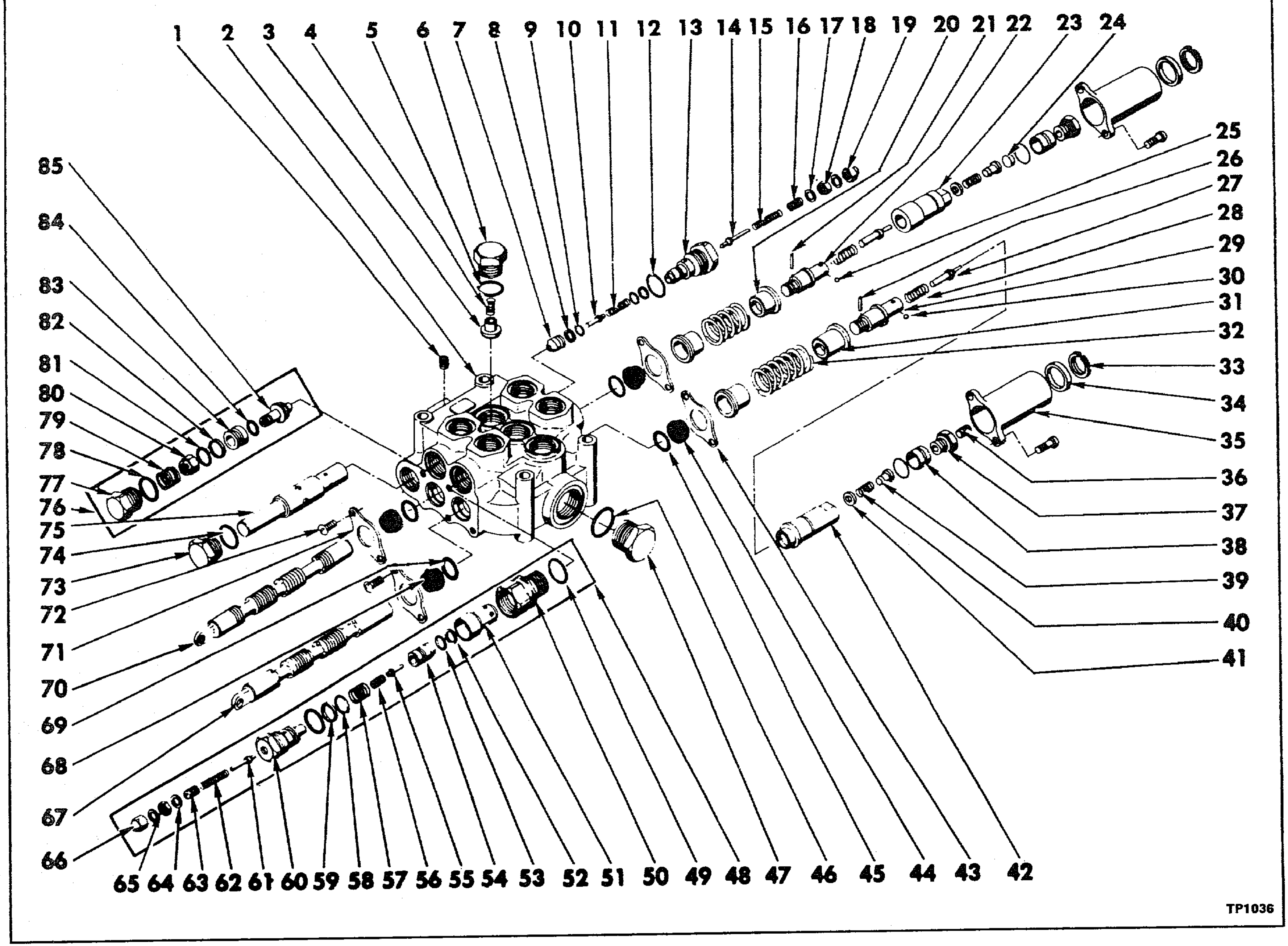
Slide the spacer on the poppet with the "O" ring in the bottom groove seating against the shoulder of the poppet. Install the stop nut on the threads of the poppet. Tighten against the spacer.

Install the spring, assembled poppet and spacer, and the "O" ring on the plug. Carefully install the assembled plug in the valve port, seating the poppet in the bore. Tighten the plug.



1. Poppet
2. "O" ring
3. Spacer
4. "O" ring
5. "O" ring
6. Stop nut
7. Plug
8. Spring
9. "O" ring
10. Backup ring

Fig. 22. Void Control Valve, Sectional View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MAIN HYDRAULIC CONTROL VALVE ASSEMBLY

(Model 3702-23F)

Item	Part No.	Description	No. Req'd.
A	2065547	Valve Assy., Main Hydraulic Control (Incl. Items 1 thru 85)	1
1	2034287	Plug, Pipe	1
2	———	Housing, Valve (N.S.S.)	1
3	6750558	Poppet, Check Valve	3
4	6750156	Spring, Check Valve	3
5	6750556	"O" Ring	3
6	6750557	Plug, Check Valve	3
7	6750334	Poppet, Relief Valve	1
8	6750337	Ring, Back-Up	2
9	6750590	"O" Ring	2
10	6750333	Piston	1
11	6750335	Spring	1
12	6750556	"O" Ring	1
13	6750578	Plug, Relief Valve	1
14	6750340	Poppet, Relief Valve Pilot	1
15	6750338	Spring	1
16	6750343	Screw, Adjusting	1
17	6750344	Washer	2
18	6750341	Nut	1
19	6750342	Nut, Acorn	1
20	6750560	Guide, Spring	2
21	6750576	Insert	1
22	6750572	Pin, Plunger	1
23	6750573	Sleeve	1
24	6750450	Spacer	1
25	6750562	Ball	3
26	6750575	Insert	1
27	6750570	Cam	2
28	6750728	Spring	2
29	6750568	Pin, Plunger	1
30	6750562	Ball	3
31	6750565	Guide, Spring	2
32	6750559	Spring	2
33	6750574	Ring, Retaining	2
34	6750571	Spacer	2
35	6750567	Cap, Plunger	2
35A	6750201	Screw, Cap	4
36	2034287	Plug, Pipe	1
37	6750458	Plug	2
38	2065329	Piston	2
38A	6750448	"O" Ring	2
39	2065330	Pin, Guide	2
40	2065331	Spring	2
41	2065332	Washer	2
42	6750569	Sleeve	1
43	6750561	Plate, Seal	2
44	6750564	Wiper	2
45	2030371	"O" Ring	2
46	6750121	Plug	1
47	2031965	"O" Ring	1
48	6750589	Valve Assy., Cylinder Relief (Incl. Items 49 thru 66)	2
49	6750556	"O" Ring	4
50	6750592	Cap	2
51	6750594	Poppet	2
52	6750337	Ring, Back-Up	2
53	6750590	"O" Ring	2
54	6750334	Poppet	2
55	6750333	Piston	2
56	6750335	Spring	2
57	6750596	Spring	2
58	6750591	"O" Ring	2
59	6750595	Ring, Back-Up	2
60	6750593	Plug	2
61	6750340	Poppet	2
62	6750338	Spring	2
63	6750343	Screw, Adjusting	2
64	6750344	Washer	4
65	6750341	Nut	2
66	6750342	Nut, Acorn	2
67	———	Plunger, Double Acting Float (N.S.S.)	1
68	6750564	Wiper	2
69	2030371	"O" Ring	4
70	———	Plunger, Double-Acting (N.S.S.)	1
71	6750561	Plate, Seal	2
72	6750176	Screw, Plate	4
73	6750555	Plug, Relief Valve	1
74	6750556	"O" Ring	1
75	6750554	Sleeve, Relief Valve	1
76	6750597	Valve Assy., Check (Incl. Items 77 thru 85)	2
77	6750598	Plug	2
78	6750556	"O" Ring	2
79	6750602	Spring	2
80	6750601	Nut	2
81	6750591	"O" Ring	2
82	6750595	Ring, Back-Up	2
83	6750599	Spacer	2
84	6750336	"O" Ring	2
85	6750600	Poppet	2

(N.S.S.) Not Serviced Separately. Order Item A.

TROUBLE	PROBABLE CAUSE	REMEDY
Sticking plungers	Excessively high oil temperature.	Eliminate restriction in pipe lines and filtering system.
	Dirt in oil.	Change oil and clean system.
	Pipe fittings too tight.	Check torque.
	Valve warped from mounting.	Loosen valve and check.
	Excessively high pressure in valve.	Check with gauge on inlet and cylinder lines.
	Handle or linkage binding.	Free up linkage.
	Plunger bent.	Replace valve.
	Return spring damaged.	Replace faulty parts.
	Spring or detent cap binding.	Loosen cap, recenter and retighten.
	Valve not thoroughly warmed up.	Let system warm up.
Leaking seals	Paint on or under seal.	Remove and clean.
	Excessive back pressure.	Open or enlarge line to reservoir.
	Dirt under seal.	Remove and clean.
	Scored plunger.	Replace valve.
	Loose seal plates.	Clean and tighten.
	Cut or scored seal.	Replace faulty parts.
Detent control fails to hold	Worn detent cam.	Replace worn parts.
	Spring or ball broken or deformed.	Replace damaged parts.
	Excessive vibration.	Insulate valve and handle linkage.
	Plunger stroke restricted.	Check linkage.
	Weight of lever excessive.	Check linkage and mechanism.
Unable to move plunger in or out	Dirt in valve.	Clean and flush out.
	Plunger cap full of oil.	Replace seals.
	Bind in linkage.	Free up linkage.
Load will not hold	Cylinder leaking or worn.	Check cylinders.
	Oil bypassing valve plunger.	Replace valve.
	Port relief valve not holding.	Remove and clean.
Load drops when plunger moved from neutral	Dirt in check valve.	Disassemble and clean.
	Scored check valve poppet or seat.	Replace poppet or lap poppet to seat.
Poor hydraulic system performance or failure	Defective pump.	Check pressure or replace.
	Dirt in relief valve.	Disassemble and clean.
	Relief valve defective.	Check as per instructions.
	Worn cylinders.	Repair or replace.
	Load too heavy.	Check line pressure.
	Internal valve crack.	Replace valve.
	Plunger not at full stroke.	Check movement and linkage.
	Oil low in reservoir.	Add oil.
	Systems filters clogged.	Clean or replace.

REMOVING MAIN HYDRAULIC PUMP FROM MACHINE

Thoroughly clean the area around the main pump mounting on the torque converter. Drain the hydraulic reservoir.

Disconnect the inlet and outlet lines to the main hydraulic pump.

Remove the bolts and lockwashers that secure the pump to the torque converter. Pull straight out on the hydraulic pump to disengage the splines from the torque converter gear.

Remove the hydraulic pump to a clean bench for disassembly.

MAIN HYDRAULIC PUMP DISASSEMBLY

Refer to the main Hydraulic pump illustration for identification of parts.

Index mark the port and cover (16), gear housing (22) and shaft end cover (12) to facilitate reassembly.

Remove the cap screws (15) and washers (15A) tha secure the port end cover (16) and gear housing (22 to the shaft end cover (12). Lift off the assembled po end cover (16), thrust plate (19), pocket seals (18 roller bearings (17), and "O" ring (21).

Remove the drive and driven gear set (20) and the gea housing (22) from the shaft end cover (12). Be sure t keep the gears together as they are a matched set. Re move the "O" ring (21) from the groove in the gea housing. Remove the thrust plate (19), roller bearing (17), spring (14), and shaft bushing (13). Remove an discard the pocket seals (18).

SHAFT END COVER DISASSEMBLY

Remove the snap ring (1) from the drive side of th cover.

shaft.

MAIN HYDRAULIC PUMP INSPECTION

Discard all "O" rings, oil seals, and pocket seals. Replace with new parts during reassembly.

Wash all parts in clean mineral oil solvent. Dry parts thoroughly and lay them on a clean, lint-free surface.

CAUTION: Never use an air hose on or near exposed parts because of the presence of water and dirt in the air system. Because of fire hazards and insurance regulations, we do not recommend gasoline or other volatile solvents such as naphtha, benzene, etc., for cleaning parts. Less flammable fluids such as kerosene or mineral spirits must be used. Never spin dry bearings using compressed air.

Lubricate the roller bearings with light oil and check them for freeness of rollers, pits, broken rollers, or excessive wear. Replace if damaged.

Check the thrust bearing roller for excessive wear and for pitting of the rollers, check the thrust bearing races for wear or pits. Replace both parts if either is damaged. Inspect the edges of the gear teeth and faces for scoring and roughness. If possible, remove roughness or scoring with an India stone. Inspect gear hubs at the bearing points. If wear exceeds .001 inch of the hub diameter, replace the gears. Gears are manufactured matched sets and must be replaced as a set, not as individual gears. Remove any roughness from the machined surfaces of the shaft end cover, gear housing, and port end cover. Replace components if roughness is excessive. Measure the gear housing bores. Replace gear housing if wear exceeds .006 inch.

Check thrust plates for erosion paths at the center, wear of the relief grooves, and wear of the running surfaces. Excessive wear is usually caused by using contaminated oil in the hydraulic system.

If any parts were repaired with the use of a stone, wash the parts after repair to remove all traces of abrasives.

NOTE: If either the gears or roller bearings have been replaced because of excessive wear, it is good practice to replace both gears and bearings. Replacement of one part and not the other will cause premature failure of the new part because it will have to conform to the wear pattern of the old part. If gears and bearings are replaced because of wear, carefully check the low pressure side of the housing bore. In most cases it will be necessary to replace the gear housing along with the gears and bearings.

roller bearings are lubricated with light oil before reassembly. Pack the thrust bearing roller with calcium base, ball bearing grease of No. 2 consistency.

Press the double lip seal (3) into the bearing sleeve (4), press the roller bearing (5) into the bearing sleeve and assemble to drive shaft (2). Install "O" ring (6) on the bearing sleeve. Place the thrust bearing race (7), thrust bearing roller (8) and thrust bearing race on the shaft. Install the snap ring retainer (9) and snap ring (10). Insert the assembled shaft into the shaft end cover (12). Replace snap ring (1).

Place the assembled shaft end cover, gear side up, in a vise with soft jaws. Install the shaft bushing (13) and spring (14) on the drive shaft (2). Be sure the bearing bores are clean; then install the two roller bearings (17) into the cover (16).

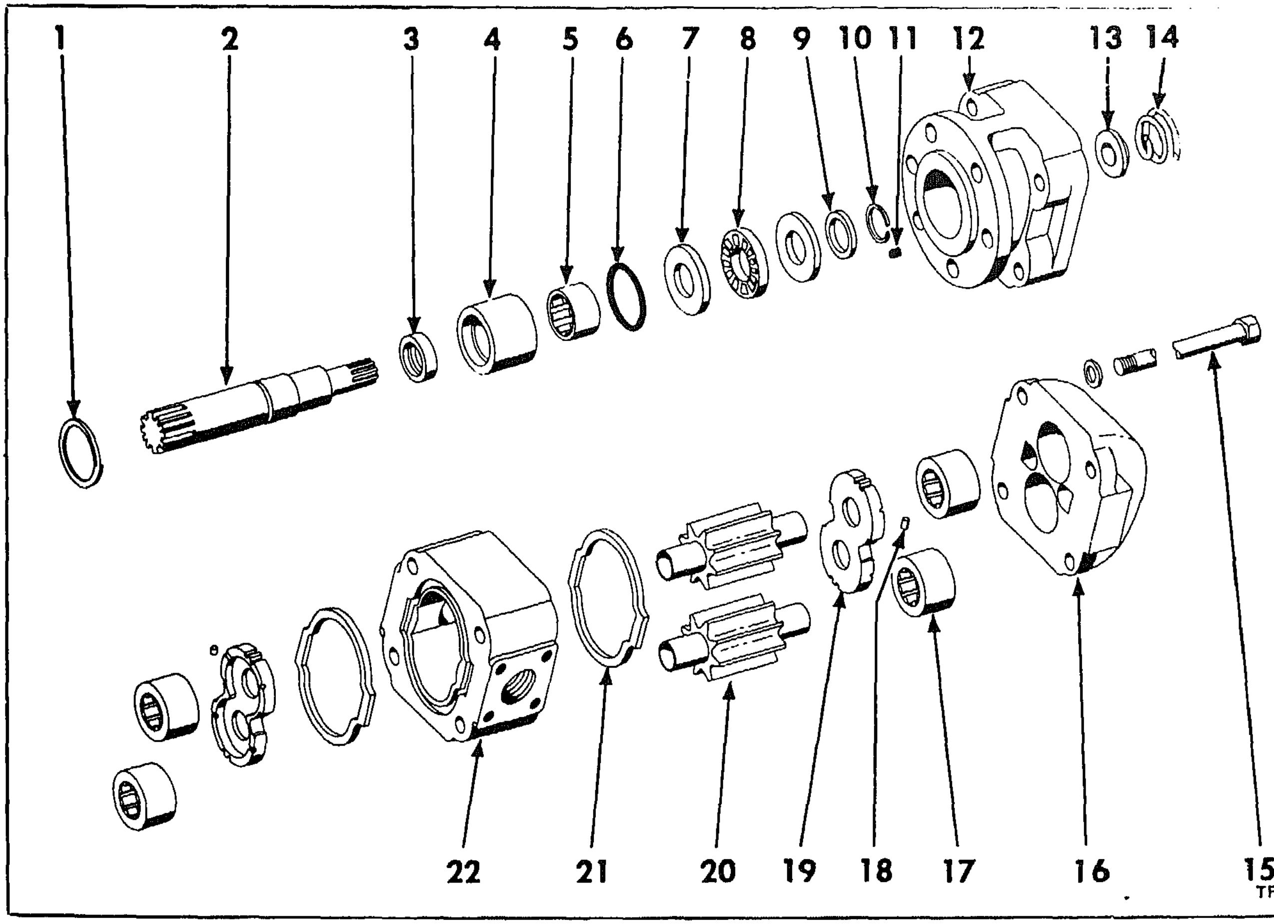
Place a small amount of heavy grease into the middle slot in the open face of the thrust plate (19) and insert pocket seal (18). Place the thrust plate with the four pocket seal slots toward the shaft end cover (12) over the bearings. Check to see that the pocket seal in the center slot is still in place and tap the thrust plate into position until a clearance of 1/32 inch is left between the thrust plate and shaft end cover.

Into each of the four open slots in the thrust plate (19), insert a pocket seal (18). Be sure to push each seal into the slot so that the hidden ends are in contact with the roller bearing races. Tap the assembled thrust plate into position and trim away the excess from the exposed ends of the pocket seals with a razor blade or sharp knife. Be sure to trim the exposed ends of the pocket seals square and flush with the thrust plate.

PORT END COVER REASSEMBLY

Install the two roller bearings (17) into their respective bores in the port end cover (16) if they were removed. Place a small amount of heavy grease in the middle slot of the thrust plate (19) and insert the pocket seal (18). Place the thrust plate with the four pocket seal slots toward the port end cover (16) over the roller bearings. Check to see that the center pocket seal is still in place. Tap the assembled thrust plate into position with a soft hammer, leaving a clearance of approximately 1/32 inch between the thrust plate and port end cover.

Into each of the four open slots in the thrust plate (19), insert a pocket seal (18). Be sure to push each seal into the slot so that the hidden ends are in contact with the roller bearing races. Tap the assembled thrust plate into position and trim away the excess from the exposed ends of the pocket seals with a razor blade or sharp knife.



MAIN HYDRAULIC PUMP

Item	Part No.	Description	No. Req'd.
A	2060274	Main Hydraulic Pump (Incl. Items 1 thru 22)	1
1	6800021	Ring, Snap	1
2	6800005	Shaft, Drive	1
3	6800018	Seal, Double Lip	1
4	6800187	Sleeve, Bearing	1
5	6800186	Bearing, Roller	1
6	6800020	"O" Ring	1
7	6800013	Race, Thrust Bearing	2
8	6800012	Roller, Thrust Bearing	1
9	6800002	Retainer, Snap Ring	1
10	6800003	Ring, Snap	1
11	6800015	Screw, Set	1

Item	Part No.	Description	No. R
12	6800022	Cover, Shaft End	1
13	6800016	Bushing, Shaft	1
14	6800017	Spring	1
15	6800262	Bolt	4
15A	6800000	Washer	4
16	6800011	Cover Assy., Port End	1
17	6800010	Bearing, Roller	4
18	6800006	Seal, Pocket	12
19	6800008	Plate, Thrust	2
20	6800246	Gear, Drive & Driven (Matched set of 2)	1
21	6800261	Gasket, "O" Ring	2
22	6800244	Housing, Gear	1

MAIN HYDRAULIC PUMP REASSEMBLY

Place the assembled shaft end cover in a vise with soft jaws, gear side up. Install the drive gear of the gear set (20). Stone the gear ends before installation to remove any minute burrs.

Install a pregreased "O" ring (21) into the groove in the gear housing (22).

Place the gear housing (22) over the gear set, lining up the index marks and tapping into position with a soft hammer. Be careful not to pinch the "O" ring when positioning the housing. Install the driven gear of the gear set (20) into its respective roller bearing bore. Pour a small amount of oil over the gears to provide initial lubrication when putting the pump back into service.

Coat the exposed face of the port end cover (12) with a thin layer of heavy grease. Install the previously lubricated "O" ring (21) into its groove in the gear housing (22).

Install the port end cover assembly on the gear housing. Hubs of gears fit into the roller bearings (17), and the thrust plates (19). Use a soft hammer to seat the port end cover assembly. When installing the cover, be sure to line up the index marks and be careful not to pinch the "O" ring.

Thread the four cap screws (15) with washers (15A) into the shaft end cover. Tighten the four cap screws alternately to 200 ft. lbs. of torque. Rotate the shaft by hand or with a 6-inch wrench. Protect the shaft splines when using a wrench.

CAUTION: After tightening the cap screws to their specified torque, be sure the drive shaft is easily rotated.

If the shaft does not rotate easily, it is an indication that the gears are binding. Disassemble the pump until the trouble is located.

Remove the assembled pump from the vise and turn it over so that the splined end of the shaft is up. Insert snap ring (1).

INSTALLING MAIN HYDRAULIC PUMP ON MACHINE

Make sure the area around the pump mounting pad of the torque converter is clean. Position the main hydraulic pump on the torque converter and secure with bolts, and lockwashers. Connect the intake and discharge lines to the pump. Fill the hydraulic reservoir with hydraulic oil as directed in the lubrication section.

steering cylinders, an external filter, and follow-up linkage.

The steering cylinders turn the frame sections. The steering cylinders are actuated by the steering control valve, located in the front frame section, which is controlled by the steering gear. A mechanical followup linkage is used to give the operator automotive steering "feel."

Hydraulic oil for steering is provided by the dual hydraulic pump. The demand valve controls the amount of hydraulic oil the steering control valve requires. The hydraulic oil is supplied from the main hydraulic reservoir mounted behind the operator.

Full steering power is available at low engine RPM as well as high engine RPM. When turning the machine, the hydraulic power is used to turn. Comoleting the turn and the operator wishes to lift the fork load, the hydraulic power is then shifted to the main hydraulic circuit thus allowing the operator to lift the fork load without oversteering the machine.

The steering hydraulic system is designed to give long, trouble-free service if properly taken care of. Special attention is given during manufacturing and shipping to insure this service.

Study the following sections of the steering system carefully to understand the service and repair of each item.

SERVICE AND REPAIR

There may be occasions when the steering hydraulic system will not function properly. This will result in jerky or erratic steering, part-time power steering or no power steering at all. When this trouble occurs, a careful inspection should be made of all external hose connections and hoses for leakage. Next check the level in the dence of leakage is found, replace the defective part or tighten a loose connection. Take care not to overtighten connections since this may damage the "O" ring seal and increase leakage. If inspection does not reveal an obvious cause of the trouble or if the correction of obvious troubles found does not correct the system trouble, it may be necessary to replace or disassemble individual units of the system. To isolate the trouble to the unit at fault, proceed as directed in the trouble shooting section.

HOSE REPLACEMENT

Replacement of hoses found to be defective will cause serious damage if they are not installed in the correct location. Correct location of hoses should first be determined before they are removed from their original position. See the steering hydraulic system installation diagram for correct hose installation.

CAUTION: Before work is performed between the machine front and rear sections, install safety link on both sides of the machine. See Fig. 5.

TROUBLE SHOOTING

Steering system filter—Check cleanliness; See filter service section.

Steering pump—Replace defective pump

Steering demand valve—Replace defective valve.

Steering valve—Replace defective valve.

Steering cylinders—See adjustment of cylinder packing. See the steering cylinder trouble shooting table. See overhaul of steering cylinders.

STEER CYLINDER OVERHAUL

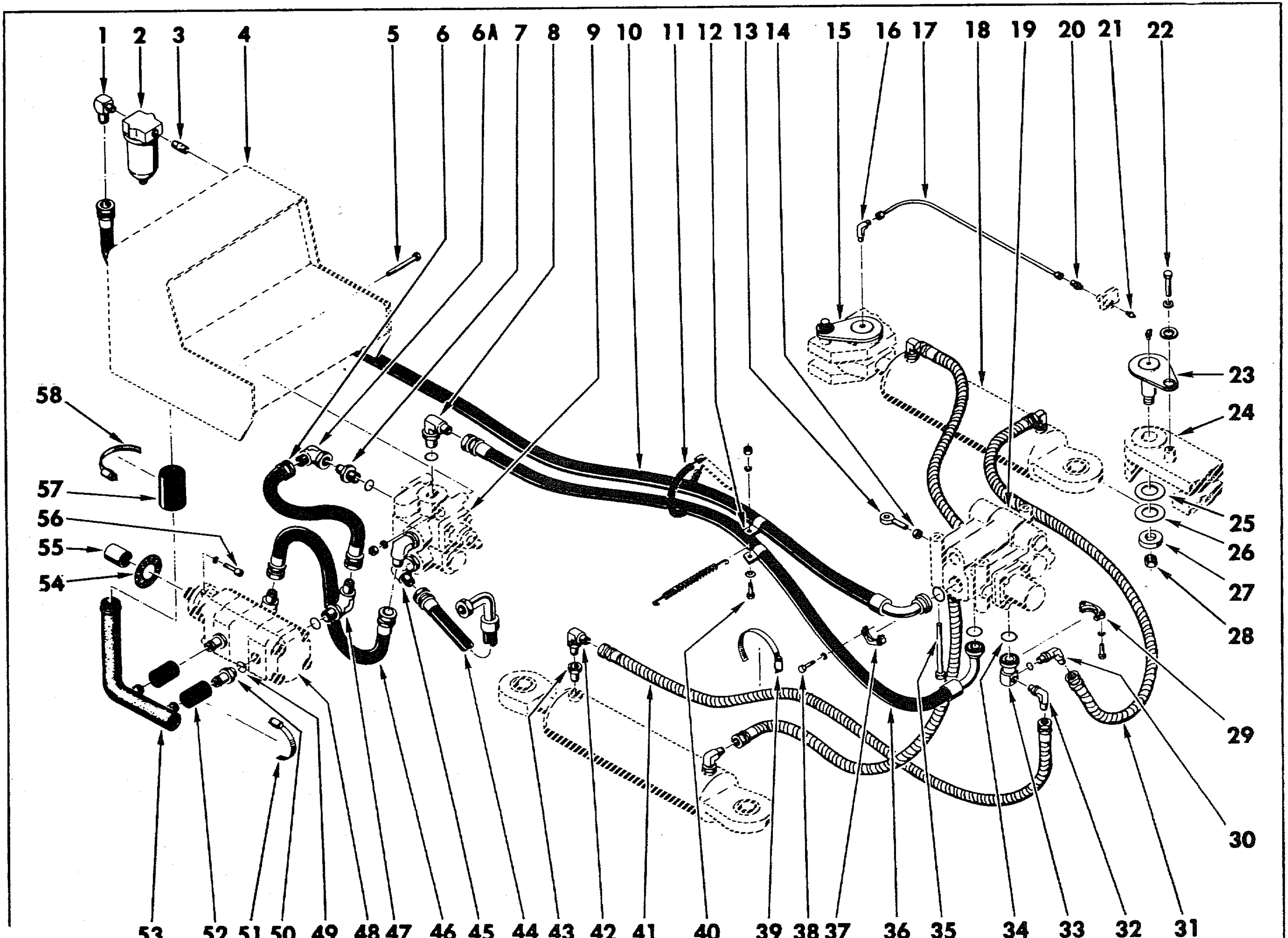
Do not disassemble either cylinder further than necessary to correct a malfunction. During disassembly, special attention should be given to identification of parts for proper reassembly.

Cleanliness is of the utmost importance. Place all disassembled parts on a clean, lint-free surface.

Steer cylinder repair kit, Part No. 6955189 contains all the sealing elements; each item may be identified by checking the steering cylinder illustration.

Before attempting to remove either cylinder, the machine must be on level terrain with the complete bottom of fork tines on the ground.

NOTE: Each time a cylinder is rebuilt, we recommend that the hydraulic oil be changed. We further recommend that cylinders be rebuilt in pairs.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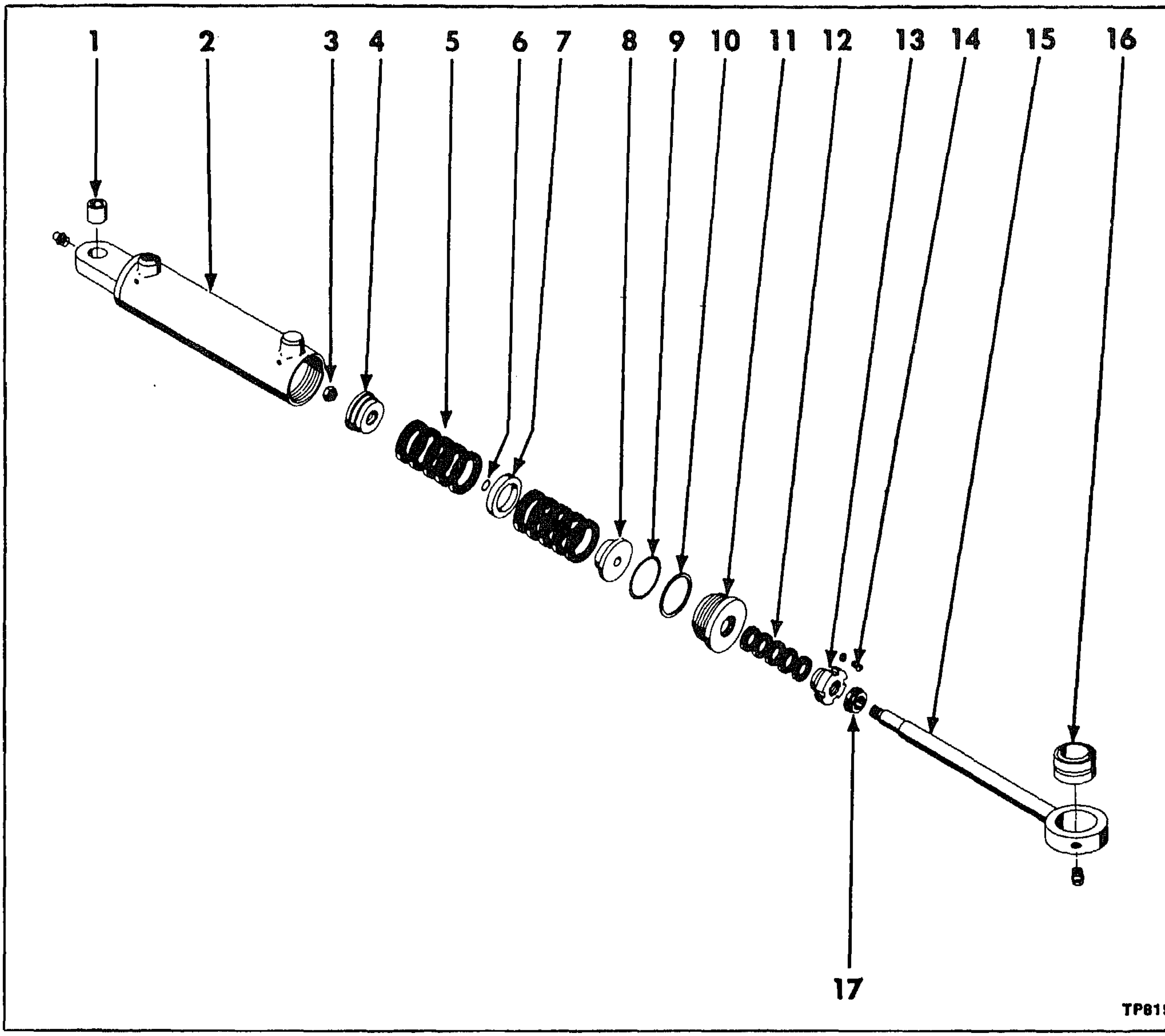
2	———	Filter (See Sep. Illus.)	
3	2033644	Nipple, Close	1
4	———	Reservoir Assy. (See Main Hydraulic System)	
5	2031490	Bolt	3
5A	2031391	Washer, Lock	3
5B	2031617	Nut	3
6	2067673	Hose	1
6A	2003074	Elbow, 90°	1
6B	6951986	End, Hose	2
7	2038901	Adaptter, Straight (Incl. Item 7A)	1
7A	2031964	"O" Ring	1
8	2031929	Elbow, 90° (Incl. Item 8A)	1
8A	2031963	"O" Ring	1
9	———	Valve, Demand (See Sep. Illus.)	
10	2067680	Hose, Valve to Filter	1
10A	6952001	End, Hose at Steer Valve	1
10B	6951989	End, Hose at Elbow	1
10C	2033306	"O" Ring	1
11	2031952	Spring	2
12	2032823	Clip	4
13	2062379	End, Rod	1
14	2033517	Nut, Jam	1
14A	2035686	Washer, Lock	1
15	———	Anchor Assy. (Reference Only)	
16	2032007	Elbow, 90°	2
17	2059923	Line, Grease	2
18	———	Cylinder, Steer (See Sep. Illus.)	
19	———	Valve, Steer (See Sep. Illus.)	
20	2031985	Adapter, Straight	2
21	2033249	Fitting, Grease	4
22	2031473	Bolt	4
22A	2031391	Washer, Lock	4
22B	2039028	Washer, Flat	4
23	2065883	Pin Assy.	4
24	———	Steer Cylinder Pivot (Reference Only)	
25	2044118	Spacer	AR
26	2044117	Spacer	AR
27	2065510	Spacer	4
28	2065879	Nut	4
29	2033315	Half, Flange	6
29A	2031477	Bolt	12
29B	2031391	Washer, Lock	12
30	2031937	Elbow, 45° (Incl. Item 30A)	2
30A	2031960	"O" Ring	2
31	2067674	Hose, Valve to Cylinder	2
31A	6951987	End, Hose	4
32	2031926	Elbow, 90° (Incl. in Item 33A)	2
33	2060264	Adapter, Flange (Incl. Item 34)	2
34	2033305	"O" Ring	2
35	2031492	Bolt	3
35A	2031391	Washer, Lock (N.I.)	3
35B	2031617	Nut (N.I.)	3
36	2067679	Hose, Demand Valve to Steer Valve	1
36A	6951994	End, Hose at Steer Valve	1
36B	6951996	End, Hose at Demand Valve	1
36C	2033305	"O" Ring	1
37	2033316	Half, Flange	2
38	2031500	Bolt	4
38A	2031392	Washer, Lock	4
39	2032041	Clamp, Hose	2
40	2031475	Bolt	2
40A	2032960	Washer, Flat	2
40B	2031391	Washer, Lock	2
40C	2031617	Nut	2
41	2067675	Hose	2
41A	6951987	End, Hose	4
42	2032011	Elbow, 90°	4
42A	2031960	"O" Ring (N.I.)	4
43	2065590	Adapter	4
43A	2031960	"O" Ring	4
44	2067678	Hose, Demand Valve to Main Control Valve	1
44A	6951988	End, Hose at Main Control Valve	1
44B	6951986	End, Hose at Demand Valve	1
45	2031940	Elbow, 45°	1
45A	2031963	"O" Ring (N.I.)	2
46	2068049	Hose, Pump to Demand Valve	1
46A	6951996	Elbow, 90° (Incl. Item 6C)	1
46B	2031929	End, Hose	2
46C	2031963	"O" Ring	1
47	2031929	Elbow, 90° (Incl. Item 47A)	1
47A	2031963	"O" Ring	1
48	———	Pump, Steer (See Sep. Illus.)	1
49	2031963	"O" Ring	2
50	2060111	Insert, Beaded	2
51	2032039	Clamp, Hose	4
52	2039149	Hose	2
53	2060302	Suction Manifold Assy.	1
54	2033267	Gasket	1
55	2043819	Adapter, Pump Drive	1
56	2044343	Bolt	6
56A	2031391	Washer, Lock	6
57	2059375	Hose	1
58	2032040	Clamp, Hose	2

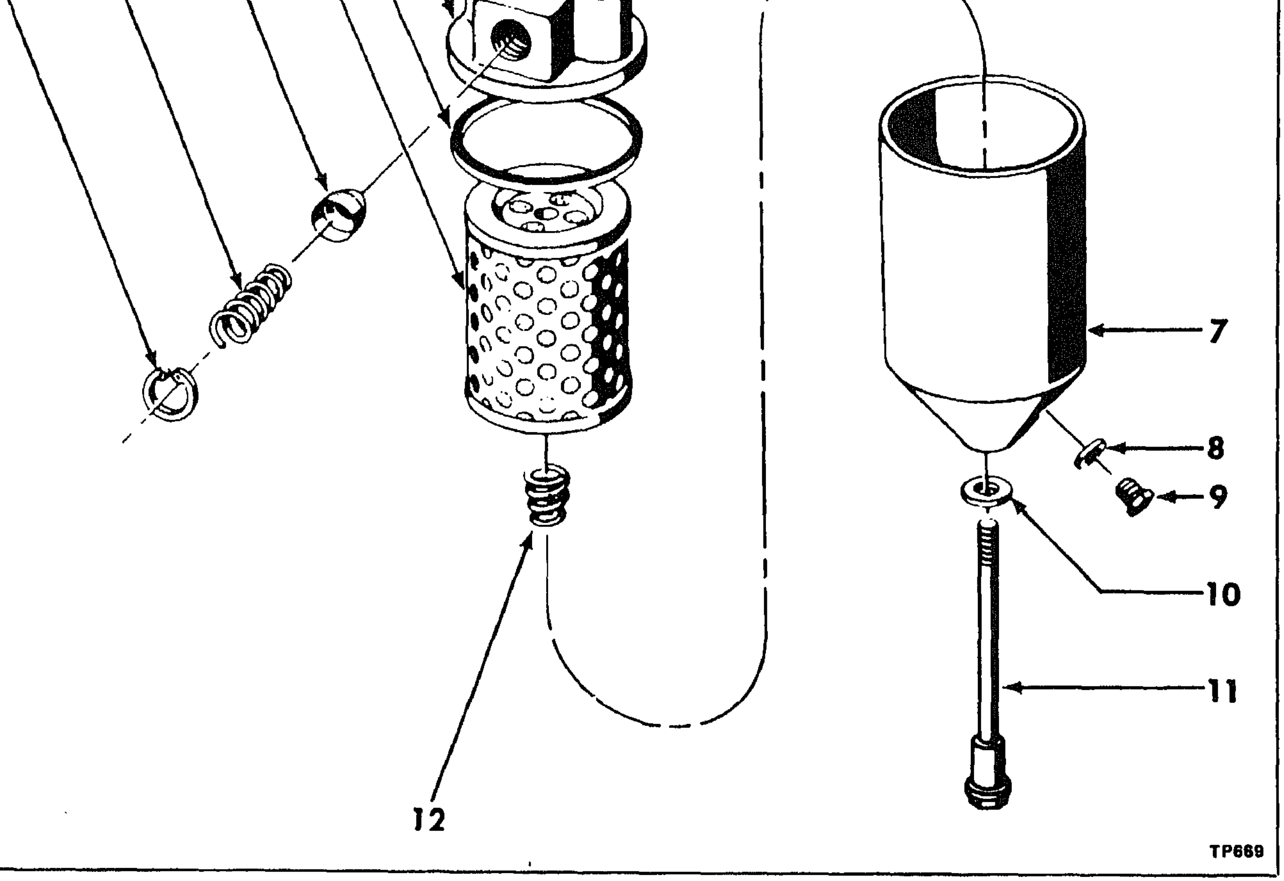
N.I. Not Illustrated AR As Required



STEERING CYLINDER

(Two Cylinders Used per Machine. Quantities Shown are for One Cylinder.)

Item	Part No.	Description	No. Req'd.
A	2059963	Steering Cylinder Assy. (Incl. Items 1 thru 17)	1
B	6955189	Kit, Cylinder Repair (Incl. Items 5, 6, 7, 9, 10, 12 & 17)	1
1	2057986	Bushing	1
2	6700331	Body Assy.	1
2A	2033383	Plug, Pipe	4
3	2032989	Nut, Esna	1
4	6700204	Piston Half	1
5	6700213	Packing, Piston	2
6	2030371	"O" Ring	1
7	6700212	Bearing, Piston	1
8	6700205	Piston Half	1
9	6700210	"O" Ring	1
10	6700209	Ring, Back-Up	1
11	6700333	Stuffing Box	1
12	6700334	Packing, Rod	1
13	2040115	Nut, Packing	1
14	6700352	Screw	1
14A	2031389	Washer, Lock	1
15	6700332	Rod Assy.	1
16	2057986	Bushing	1
17	2040116	Wiper	1



STEERING HYDRAULIC FILTER

Part No.	Description	No. Req'd.
2048624	Filter Assy. (Incl. Items 1 thru 12)	1
6955057	Kit, Gasket (Incl. Items 5, 8 & 10)	1
6950365	Ring, Retaining	1
6951374	Washer	1
6950364	Spring	1
6950363	Poppet	1
6955169	Kit, Element (Incl. Item 5)	1

Item	Part No.	Description	No. Req'd.
5	———	Gasket (N.S.S.)	1
6	6950357	Base	1
7	6951372	Body	1
8	———	Gasket (N.S.S.)	1
9	6950359	Plug (When Used)	1
10	6951373	Gasket	1
11	6950362	Bolt	1
12	6950361	Spring	1

.S.) Not Serviced Separately

REMOVING STEER CYLINDER FROM MACHINE

Refer to hydraulic steering illustration for identification of parts.

Disconnect the hose connections at front and rear of the cylinder.

Provide a means of holding and moving the cylinder after removal. A chain hoist or sufficient manpower would be suitable. Allowing the cylinder to drop could result in damage to the cylinder or injury to persons working on the machine.

Remove the bolts and washers securing pin assemblies (24) and lock plates (28), to the bosses on the steer cylinder pivots at both the head and rod assembly ends. Remove the pin assemblies.

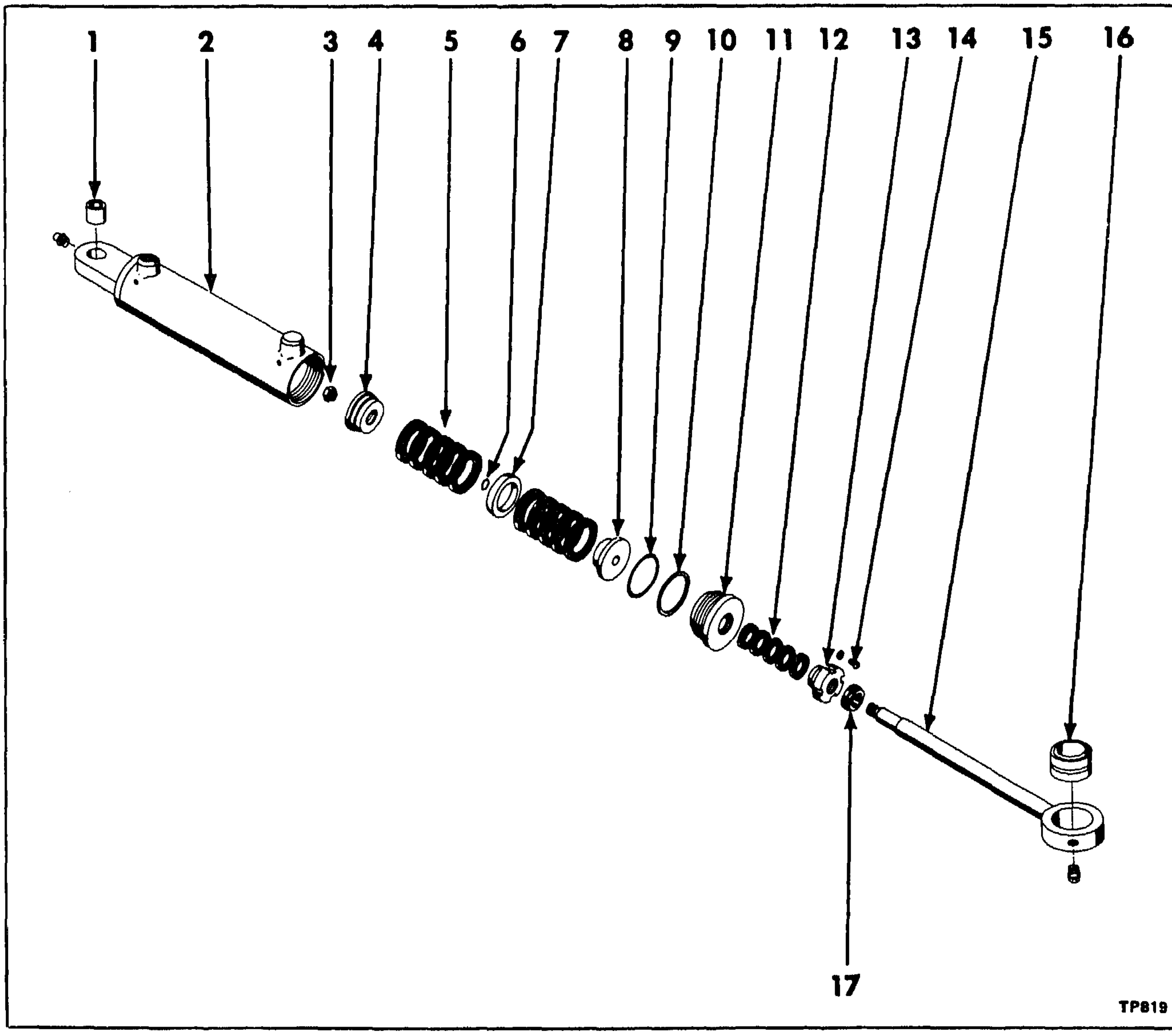
STEER CYLINDER DISASSEMBLY

Refer to steering cylinder illustration for identificatio of parts.

During disassembly, clean all parts except sealin elements in clean mineral oil solvent. After dryin thoroughly, lay parts on a clean, lint-free surface fo inspection. Never use an air hose on or near the expose parts because of the presence of water and dirt in th system.

Pull rod assembly (15) to its full extension; use spanner wrench to unscrew and remove stuffing bo (11) from the cylinder. During and after this opera tion, the rod assembly must be held by hand, in th center of the cylinder (2), to protect the inner walls o the cylinder from being scratched by the assemble piston (4) and (8).

STEERING CYLINDER



Pull the rod assembly and piston assembly from the cylinder by hand, being very careful not to scratch the inner walls. Keep rod assembly in the center diameter of the cylinder. Place the head end of the rod assembly in a machinist's vice, using protective jaws.

Remove nut (3), piston halves (4) and (8) with piston packing (5), "O" ring (6), and piston bearing (7) from rod assembly (15).

Remove the "O" ring (9) and backup ring (10) from the stuffing box (11).

Remove the rod assembly from the vise. Place the stuffing box (11) in the vise and remove set screw (14) and lockwasher (14A).

Using a spanner wrench, unscrew packing nut (13) and remove from stuffing box (11). Use a hook scriber or suitable tool to remove wiper ring (17) from packing nut. Remove packing (12).

STEER CYLINDER INSPECTION

Discard all sealing elements and replace with new.

Check each disassembled part for wear, cracks or pitting that would render them unfit for further use. Pay particular attention to the inner walls of the steering cylinder and the surface of the rod assembly.

Inspect the pin assemblies (24) for wear or scoring; replace if necessary.

Inspect the bushing (1) and (16) and replace if worn, scored or loose.

STEER CYLINDER REASSEMBLY

Coat each part with a film of clean hydraulic oil to facilitate reassembly. Prior to assembly, liberally coat all sealing elements with petroleum jelly.

Replace backup ring (10) and "O" ring (9) on stuffing box (11).

Place stuffing box in vise and install packing (12). Work each ring down smoothly without distortion or damage. Be very careful; a damaged ring must be discarded and a new set purchased. Use a flat tool to work in the new rings, taking care not to cut the rings or damage the stuffing box threads. Install packing nut (13) with wiper ring (17).

Remove stuffing box from vise. Place rod assembly (15) in vise. Slide stuffing box onto rod assembly. Install piston half (8) on the rod until it bottoms. Install "O" ring (6) in the piston half recess.

Place one set of packing (5) snugly in piston half.

Place one set of packing (5) snugly in the piston half (4) and install the piston on the rod assembly.

Install the halves of the piston bearing (7) between the piston halves (4) and (8). Turn nut (3) on the rod assembly and tighten to 30 lb. ft. torque.

Remove the rod assembly from the vise, with the cylinder (2) held securely, place the piston and rod assembly in the center of the diameter and push the piston and rod firmly in, being careful not to scratch the inner

Now that the piston is in the cylinder, oil the inner cylinder walls again and install the stuffing box (11), being careful not to unseat the "O" ring (9), or backup ring (10). Very carefully push the piston in until it bottoms on the base of the cylinder. Use a spanner wrench to tighten stuffing box securely. Draw packing nut (13) up snugly with spanner wrench. A properly adjusted nut will allow a light film of oil to remain on the rod assembly as it is drawn out of the cylinder.

Replace lockwasher (14A) and set screw (14).

By means of a chain hoist or sufficient manpower lift the cylinder into position.

Replace the pin assemblies (24) and lock plates (28) to the bosses on the steer cylinder pivots at both the head and rod assembly ends. Secure the pin assemblies by replacing the bolts and washers.

Drain the hydraulic oil and refill the system whenever a cylinder is replaced. Lubricate the mounting bushings; refer to the lubrication section.

Each time the steering cylinders are rebuilt, the steering hydraulic system must be bled to remove air present in the system. Two bleeder plugs have been provided, one on each end of the steering cylinders for this purpose. Make up oil added to the reservoir after bleeding must be clean new oil.

DEMAND VALVE ASSEMBLY

Refer to the demand valve illustration for identification of parts.

The demand valve is pre-set at the time of manufacture and should not require additional adjustment.

Should the demand valve be suspected of being defective, the valve should be disassembled, cleaned and all parts inspected for wear.

Replace all seals and defective parts.

When removing cap (8) do not remove or tamper with adjusting screw (11) or nut (10).

Stool (2) and housing (1) are machined together and cannot be re-matched to other parts.

Replace complete valve if these parts are defective.

STEERING CONTROL VALVE

Refer to the steering valve illustration for identification of parts.

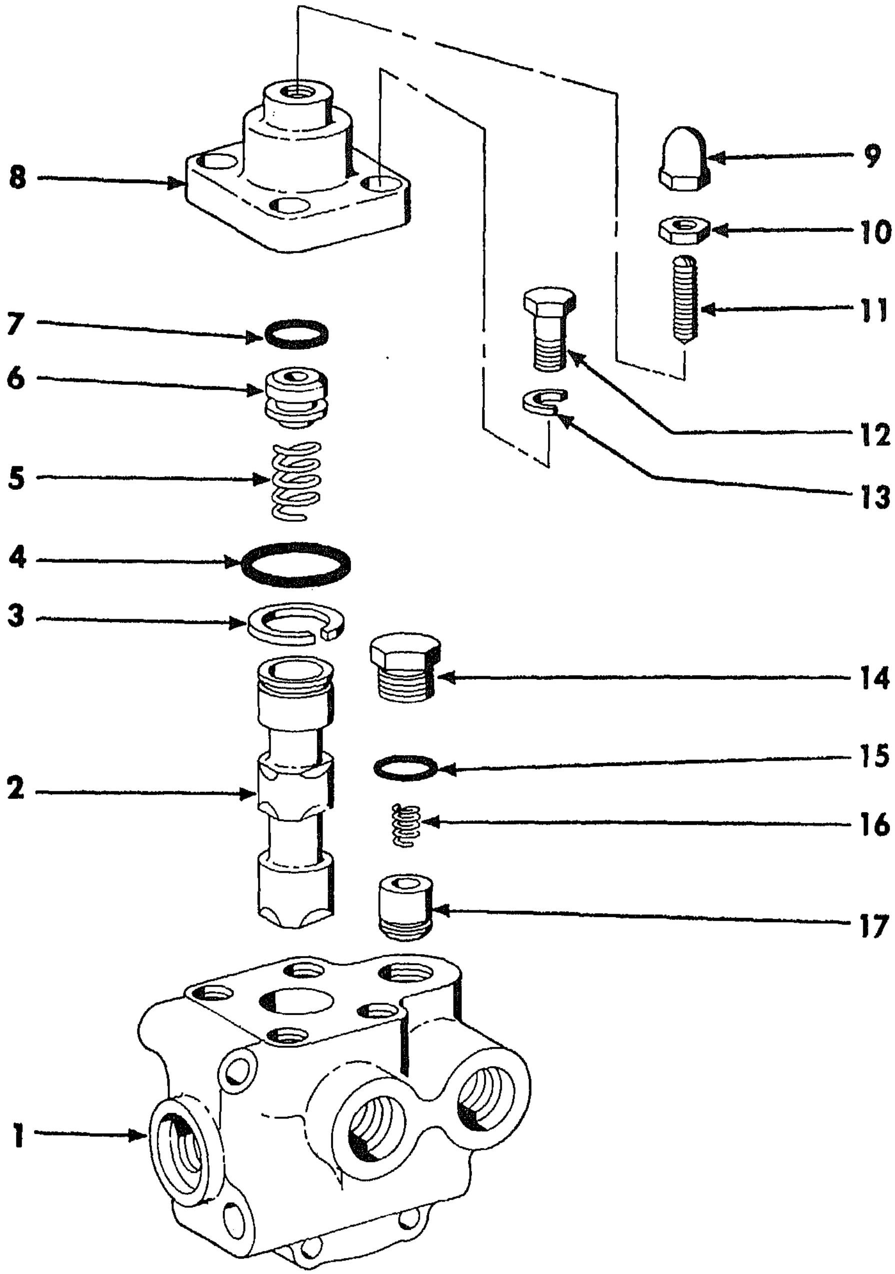
The steering valve assembly is pre-set at time of manufacture and normally will not require periodic adjustment.

In the event trouble is suspected in the valve assembly, refer to the trouble shooting chart to define trouble and remedy. Should this not correct the problem, perform the following operations:

Remove the main poppet assembly (15) and replace with new poppet.

Remove the left and right turn poppets (4) and replace with new poppets.

After replacing the directional and main poppets' if the valve does not function correctly, the complete valve

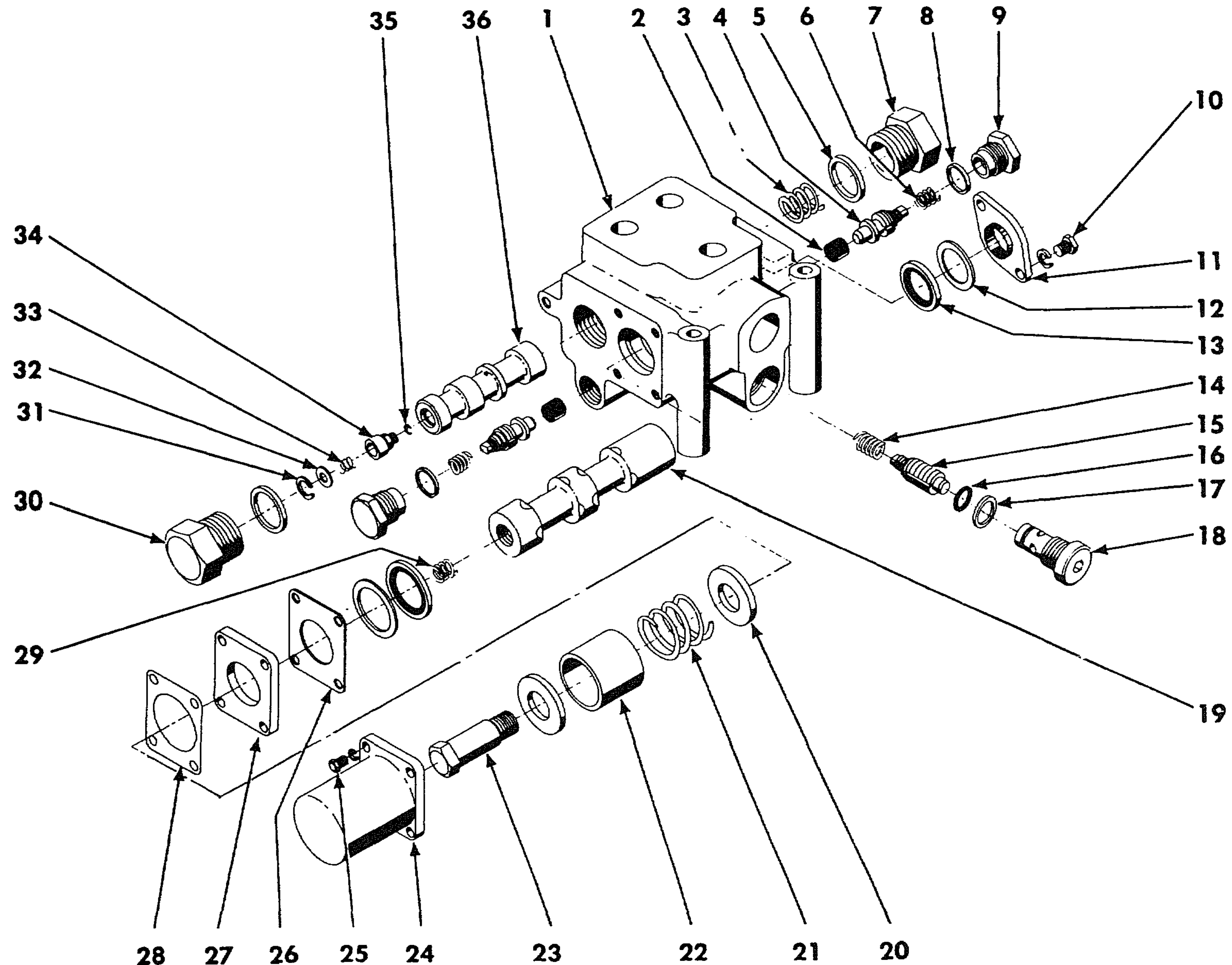


TP811

Item	Part No.	Description	No. Req'd.
A	2060265	Demand Valve Assy. (Incl. Items 1 thru 17)	1
1	———	Housing (N.S.S. Order Item A)	1
2	———	Plunger (N.S.S. Order Item A)	1
3	6750640	Ring, Retaining	1
4	6750631	"O" Ring	1
5	6750639	Spring	1
6	6750632	Guide, Spring	1
7	6750635	"O" Ring	1
8	6750634	Cover	1
8A	2040148	"O" Ring (N.I.)	1
9	6750637	Nut, Acorn	1
10	2033517	Nut, Jam	1
11	6750636	Screw, Adj.	1
12	2031501	Capscrew	4
13	6750139	Washer, Lock	4
14	6750633	Cap	1
15	6750459	"O" Ring	1
16	6750638	Spring	1
17	6750068	Check	1
18	2040148	"O" Ring	1

N.S.S.) Not Serviced Separately

(N.I.) Not Illustrated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n	Part No.	Description	No. Req'd.
	2060272	Steering Valve Assy., (Incl. Items 1 thru 36)	1
	6955215	Service Kit, Main Relief Valve (Incl. Items 14, 15, 16, 17 & 18)	1
	6955216	Service Kit, Relief Valve (Incl. Items 4, 6 & 8)	2
	———	*Housing* (N.S.S. Order Item A)	1
	6750644	Seat	2
	6750662	Spring	1
	6750646	Poppet Assy.	2
	6750670	Ring, Sq.	2
	6750661	Spring	2
	6750651	Cap	1
	6750668	Ring, Sq.	2
	6750649	Cap	2
	2031427	Screw, Cap	2
A	2031389	Washer, Lock	2
	6750330	Wiper & Retainer Assy.	1
	6750055	Ring, Back-Up	2
	6750671	Seal	2
	6750660	Spring	1
	6750647	Poppet Assy.	1

Item	Part No.	Description	No. Req'd.
16	6750027	"O" Ring	1
17	6750669	Ring, Sq.	1
18	6750645	Seat	1
19	———	Plunger (N.S.S. Order Item A)	1
20	6750658	Washer	2
21	6750664	Spring	1
22	6750654	Spacer	1
23	6750672	Bolt, Shoulder	1
24	6750659	Cover	1
25	2031431	Screw, Cap	4
25A	2031389	Washer, Lock	4
26	6750655	Shim	AR
27	6750653	Spacer	1
28	6750656	Shim	AR
29	6750665	Spring	1
30	6750652	Cap	1
31	6750666	Ring, Retaining	1
32	6750657	Washer	1
33	6750663	Spring	1
34	6750648	Check	1
35	6750667	Wire, Orifice	1
36	———	Plunger (N.S.S. Order Item A)	1

As Required

(N.S.S.) Not Serviced Separately

TROUBLE	PROBABLE CAUSE	REMEDY
Loss of Steering	No oil supply.	Check reservoir level. Check output from demand valve. Check for broken hoses, leaks, etc.
	Main steer relief valve stuck open.	Check for dirt and free movement of cartridge; clean screen carefully; replace cartridge if necessary.
	Mechanical steering linkage broken or disconnected.	Repair as required.
	Lock-up spool stuck in "locked" position.	Check for dirt and free movement in bore. Check for free movement of pilot valve in lock-up spool.
Erratic Steering	Main relief valve not always seating.	Check for dirt and free movement of cartridge on bore. Clean screen carefully, replace cartridge if necessary.
Loss of left or right steering	Circuit relief valve stuck open.	Check for dirt and free movement of cartridge in bore. Clean screen carefully, replace cartridge if necessary.
Steers without moving steering wheel	Steer valve plunger not centered.	Add or subtract shims to center plunger.
	Steering linkage improperly adjusted.	Adjust so plunger remains in neutral.
Slow steering at low engine speeds	Incorrect steering hydraulic oil output from demand valve.	Defective steering and/or demand hydraulic pump —Repair.
Fast steering at high engine speeds	Incorrect demand valve operation.	Replace demand valve.
MAIN HYDRAULIC TROUBLE Slow main hydraulic system operation at high engine speeds	Low main hydraulic output from demand valve.	Check main hydraulic valve under main hydraulic valve. Defective steering hydraulic pump—Repair. Defective demand pump—Repair.

The main plunger (19) is pre-set at the time of manufacture by means of shims between the plunger end cap and spacer. Any time the cap is removed or replaced, no shims should be added or removed. The old cap counterbore should be carefully measured and compared with the new cap. Add or delete shims as required so that the length is identical to the old cap.

Torque shoulder bolt to 45 to 50 lbs. ft. torque.

The complete valve should be replaced if the problem is not corrected in overhaul.

Spools (36) and (19) are machined to housing (1) therefore replacement should be with a complete valve.

Thoroughly clean the area around the steering hydraulic pump mounting on the torque converter. Drain the hydraulic reservoir.

Disconnect the inlet and outlet lines to the steering hydraulic pump.

Remove the bolts and lockwashers that secure the pump to the torque converter. Pull straight out on the hydraulic pump to disengage the splines from the torque converter gear.

Remove the hydraulic pump from the torque converter.

Move it to a clean bench for disassembly.

STEERING HYDRAULIC PUMP DISASSEMBLY

Refer to the steering hydraulic pump illustration for identification of parts.

Index mark the port end cover (19), gear housings (10), bearing carrier (24), and shaft end cover (31) to facilitate reassembly.

Remove the four hex nuts (18) and washers (16) from the studs.

Lift off the assembled port end cover (19), thrust plate (9), pocket seals (15), and roller bearings (8).

Remove the drive and driven gear set (23) and the gear housing (10) from the bearing carrier (24). Be sure to keep the gears together as they are a matched set.

Remove four studs (17).

Using a wrench to hold the drive end of shaft (2), remove lock nut (20) from connecting studs (22). Protect end of shaft when using wrench.

Remove spacer (21) and connecting shaft (12) from connecting stud (22).

Remove the bearing carrier (24) from the gear housing (10). The thrust plates (9), with pocket seals (15), roller bearings (8), shaft bushings (14) will also be removed.

Remove drive and driven gears (23) and gear housing (10) from the shaft end cover (31). Keep the gears together as they are a matched set.

Remove connecting stud (22) from tapped hole in gear end of shaft (2).

Remove spacer (21) from connecting stud (22).

SHAFT END COVER DISASSEMBLY

Remove the snap ring (1) from the drive side of the cover.

thrust plate carefully with a knife blade or thin screw driver. Remove and discard the pocket seals.

Pull the bearings (8) with a bearing puller from the shaft end cover (31) ONLY—if they are being replaced. To remove conical spring (7) and shaft bushing (6) only the shaft end drive bearing need be removed.

Remove snap ring (30) and snap ring retainer (29) from shaft. Press bearing sleeve (4), lip seal (3), races (27) and thrust bearing rollers (28) from shaft (2).

Remove and discard "O" ring and lip seal from sleeve bearing.

HOUSING DISASSEMBLY

Remove and discard "O" rings (11) from gear housings (10).

PORT END COVER DISASSEMBLY

Pry off the thrust plate (9) with a knife blade or thin screw driver. Remove and discard the pocket seals (15). Pull the bearings (8) with a bearing puller from the port end cover (19), ONLY if they are being replaced.

BEARING CARRIER DISASSEMBLY

Pry off the thrust plates (9) with a knife blade or thin screw driver. Remove and discard pocket seals (15).

Pull the four bearings (8) with a bearing puller from the bearing carrier (24), ONLY if they are being replaced.

Remove the two shaft bushings (14). Remove the two roll pins (13).

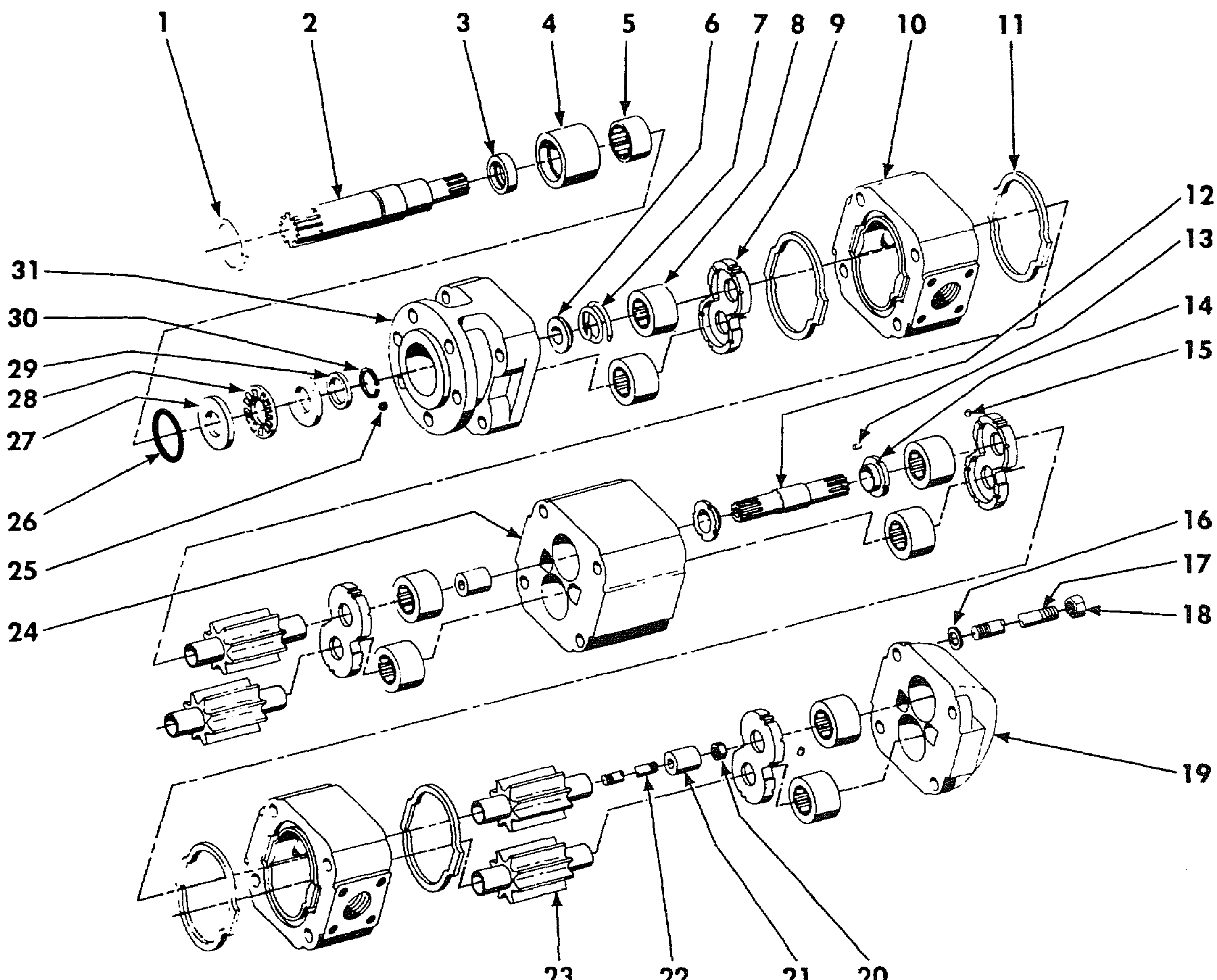
STEERING HYDRAULIC PUMP INSPECTION

Discard all "O" rings, oil seals, and pocket seals. Replace with new parts during reassembly.

Wash all parts in clean mineral oil solvent. Dry parts thoroughly and lay them on a clean, lint-free surface.

CAUTION: Never use an air hose on or near exposed parts because of the presence of water and dirt in the air system. Because of fire hazards and insurance regulations, we do not recommend gasoline or other volatile solvents such as naphtha, benzene, etc., for cleaning parts. Less flammable fluids such as kerosene or mineral spirits must be used. Never spin dry bearings using compressed air.

Lubricate the roller bearings with light oil and check them for freeness of rollers, pits, broken rollers, or excessive wear. Replace if damaged.



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Inspect the edges of the gear teeth and faces for scoring and roughness. If possible, remove roughness or scoring with an India stone. Inspect gear hubs at the bearing points. If wear exceeds .001 inch of the hub diameter, replace the gears. Gears are manufactured matched sets and must be replaced as a set, not as individual gears.

Remove any roughness from the machined surfaces of the shaft end cover, gear housing, and port end cover. Replace components if roughness is excessive. Measure the gear housing bores. Replace gear housing if wear exceeds .006 inch.

Check thrust plates for erosion paths at the center, wear of the relief grooves, and wear of the running surfaces. Excessive wear is usually caused by using contaminated oil in the hydraulic system.

If any parts were repaired with the use of a stone, wash the parts after repair to remove all traces of abrasives.

NOTE: If either the gears or roller bearings have been replaced because of excessive wear, it is good practice to replace both gears and bearings. Replacement of one part and not the other will cause premature failure of the new part because it will have to conform to the wear pattern of the old part. If gears and bearings are replaced because of wear, carefully check the low pressure side of the housing bore. In most cases it will be necessary to replace the gear housing along with the gears and bearings.

GEAR PUMP SHAFT END COVER REASSEMBLY

NOTE: Lubricate all "O" rings and oil seals with sticky grease before reassembly. Make sure all straight roller bearings are lubricated with light oil before reassembly. Pack the thrust bearing roller with calcium base, ball bearing grease of No. 2 consistency.

STEERING PUMP REASSEMBLY

Place the shaft end cover (31), gear side up, in a vise with soft jaws. Install bronze shaft bushing (6) with flange side toward bottom of bore.

Next, install conical spring (7) with smaller end of spring over pilot shoulder of shaft bushing.

Install two roller bearings (8) in the bores of the cover —IF—they were removed. Be sure top of spring (7) does not become wedged between bearing and bottom of bearing counterbore.

(4) with lip of the seal facing outward. Install "O" ring (26) on the bearing sleeve (4). Next, press roller bearing (5) into sleeve bearing. Install the assembled parts on the shaft (2) with lip seal toward larger diameter spline. Place the races (27) with the thrust bearing rollers (28) between them on the shaft. Slide the snap ring retainer (29) on next and put the snap ring (30) in position on the shaft groove.

Insert the assembled shaft in shaft end cover (31). Replace snap ring (1) in cover.

Turn shaft end cover over in vise with gear side up. See that a set screw is installed in the high pressure side of pump with the low pressure side left open.

Place a small amount of heavy grease into the two middle slots in the open face of the thrust plate (9) and insert pocket seals (15). Place the thrust plate with the pocket seal slots toward the shaft end cover (31) over the bearings (8). Check to see that the pocket seals (15) in the center slots are still in place and tap the thrust plate into position until a clearance of 1/32 inch is left between the thrust plate and shaft end cover.

Into each of the four open slots in the thrust plate (9), insert a pocket seal (15). Be sure to push each seal into the slot so that the hidden ends are in contact with the roller bearing races. Tap the assembled thrust plate into position and trim away the excess from the exposed ends of the pocket seals with a razor blade or sharp knife. Be sure to trim the exposed ends of the pocket seals square and flush with the thrust plate.

PORT END COVER REASSEMBLY

Install the two roller bearings (8) into their respective bores in the port end cover (19) if they were removed. Place a small amount of heavy grease into the two middle slots of the thrust plate (9) and insert the pocket seals (15). Place the thrust plate with the pocket seal slots toward the port end cover (19) over the roller bearings. Check to see that the center pocket seals are still in place. Tap the assembled thrust plate into position with a soft hammer, leave a clearance of approximately 1/32 inch between the thrust plate and port end cover.

Into each of the four open slots in the thrust plate (9), insert a pocket seal (15). Be sure to push each seal into the slot so that the hidden ends are in contact with the roller bearings races. Tap the assembled thrust plate into position and trim away the excess from the exposed ends of the pocket seals with a razor blade or sharp knife.

STEERING PUMP ASSEMBLY

Item	Part No.	Description	No. Req'd.
A	2060163	Steering Pump Assy. (Incl. Items 1 thru 31)	1
1	6800021	Ring, Snap	1
2	6800005	Shaft, Drive	1
3	6800018	Seal, Double Lip	1
4	6800187	Sleeve, Bearing	1
5	6800186	Bearing, Roller	1
6	6800016	Bushing, Shaft	1
7	6800017	Spring	1
8	6800010	Bearing, Roller	8
9	6800008	Plate, Thrust	4
10	6800235	Housing, Gear	2
11	6800261	Gasket, Seal	4
12	6800238	Shaft, Connecting	1
13	6800239	Pin, Roll	2
14	6800222	Bushing, Shaft	2
15	6800006	Seal, Pocket	24
16	6800000	Washer	4
17	6800242	Stud	4
18	6800243	Nut	4
19	6800011	Cover, Port End	1
20	6800241	Nut, Lock	1
21	6800232	Spacer	2
22	6800240	Stud, Connecting	1
23	6800236	Gears, Drive & Driven (Matched Set of 2)	2
24	6800237	Carrier, Bearing	1
25	6800015	Screw, Set	1
26	6800020	"O" Ring	1
27	6800013	Race, Thrust Bearing	2
28	6800012	Rollers, Thrust Bearing	1
29	6800002	Retainer, Snap Ring	1
30	6800003	Ring, Snap	1
31	6800022	Cover, Shaft End	1

BEARING CARRIER REASSEMBLY

Install the two roll pins (13) in the holes provided for them in the drive shaft bores.

Install two shaft bushings (14) in the shaft holes so that flange side of each bushing will be against bottom of bearing bore. Fit one slot of bushing over roll pin. This prevents bushing from turning on shaft. Do one side at a time.

Install four roller bearings (8) IF they were removed. Place small amount of heavy grease into the two middle slots in the open face of the thrust plate (9) and insert pocket seals (15).

Place the thrust plate (9) with pocket seal slots toward the face of the bearing carrier (24) over the bearings (8). Check to see that the pocket seals in the center slots are still in place before tapping the thrust plate into position. Leave a clearance of approximately 1/32 inch between the thrust plate (9) and the bearing carrier (24).

Into each of the four open slots in the thrust plate (9) insert a pocket seal (15). Push each seal all the way into the slot so that the hidden end is always in contact with the roller bearing race. Tap the assembled thrust plate into position against the face of the bearing carrier. Using a razor blade or sharp knife, trim away the excess from the exposed ends of the pocket seals square and flush with sides of the thrust plate.

STEERING HYDRAULIC PUMP REASSEMBLY

Place the assembled shaft end cover in a vise with soft jaws, gear side up. Install the drive gear of the gear set (23). Stone the gear ends before installation to remove any minute burrs.

Install pregreased "O" rings (11) into the grooves in the gear housings (10).

Place the gear housing (10) over the gear set, lining up the index marks and tapping into position with a soft hammer. Be careful not to pinch the "O" ring when positioning the housing. Install the driven gear of the gear set (23) into its respective roller bearing bore. Pour a small amount of oil over the gears to provide initial lubrication when putting the pump back into service.

Install spacer (21) and then the connector shaft (12) into the bore of the drive gear (23).

Insert the shaft connecting bolt (22) through the bore of the connector shaft (12) and thread into tapped hole in the end of the drive shaft. Use locktite sealant on end of bolt before threading. Place other spacer (21) on bolt (22) and then install lock nut, but do n tighten nut.

Install the bearing carrier (24) on the gear housi (10). Care must be taken so as not to score the sha bushing in the shaft bore.

Tap bearing carrier (24) in place with a soft hamm being careful not to pinch "O" ring (11), in the fa of the housing (10).

Install drive gear (23) over the connector shaft (12 spacer (21), and lock nut.

Install the driven gear (23) into its respective bo Next, hold drive end of shaft with wrench and tight locknut. If nut is tightened before installing drive ge (23) be sure spacer (21) is centered on connector sha (12).

Place gear housing (10) over gears (23) and tap in place against bearing carrier. Pour a small amount oil over the gears to provide lubrication when putti pump back into service.

Install the port end cover assembly on the gear housin Hubs of gears fit into the roller bearings (8), and t thrust plates (9). Use a soft hammer to seat the po end cover assembly. When installing the cover, be su to line up the index marks and be careful not to pin the "O" rings.

Thread the four studs (17) into the shaft end cove leaving enough thread protruding above the port er cover to accommodate the washers (16) and hex nu (18). Tighten the four nuts alternately to 200 ft. lb of torque. Rotate the shaft by hand or with a 6-inc wrench. Protect the shaft splines when using a wrenc

CAUTION: After tightening the nuts to their specifie torque, be sure the drive shaft is easi rotated.

If the shaft does not rotate easily, it is an indicatio that the gears are binding. Disassemble the pump un the trouble is located.

Remove the assembled pump from the vise and turn over so that the splined end of the shaft is up. Inse snap ring (1).

INSTALLING STEERING HYDRAULIC PUMP ON MACHINE

Make sure the area around the pump mounting pad the torque converter is clean. Position the main h draulic pump on the torque converter and secure wi bolts, and lockwashers. Connect the intake and di charge lines to the pump. Fill the hydraulic reservo with hydraulic oil as directed in the lubrication sectio

hydraulic system, properly adjusted and free from defect, controls the steering function of your machine. The linkage requires very little maintenance except for lubrication and minor adjustment. A complete maintenance program should be set up and followed to give this system top performance and trouble free service. See lubrication and adjustment sections.

STEERING GEAR ASSEMBLY

The steering gear is a mechanical type. It is controlled by turning the steering wheel mounted on top of the column. See overhaul of steering gear assembly.

STEERING TIE ROD

The steering tie rod is connected with a ballstud to the pitman arm on the left side of the steering gear housing. The other end is connected with a ball stud to the steering bellcrank mounted to the top main pivot.

STEERING BELLCRANK

The steering bellcrank connects the steering tie rod to the steering rod. The opposite end of the rod is connected by means of an eye bolt screwed into the steering valve. The eye bolt is secured to the steering valve plunger with a jam nut.

TROUBLE SHOOTING

Defective steering may be caused by worn or damaged steering linkage components. Before major overhaul of the steering hydraulic system is performed, make the following checks in the steering linkage:

STEERING GEAR ASSEMBLY

With the machine on level ground, start engine. Slowly turn the steering wheel in both directions. Observe the steering linkage movement as the wheel is being turned. haul of steering gear assembly.

STEERING TIE ROD

Two ball studs are securely held in position at each end of the tie rod. Pressure required to hold the ball studs is determined by the adjusting plugs located in each end. To adjust the plugs, first remove the cotter pins and turn plug in to increase pressure and out to decrease pressure. With the correct adjustment made, reinstall cotter pins.

Periodically remove the ball studs, seats and springs from ends of tie rod. Inspect all parts for damage and wear. Replace if necessary.

STEERING ROD

The steering rod, along with other linkage is adjusted at the factory. Little or no maintenance is required except to check jam nuts for tightness and minor adjustment. Adjustment can be accomplished by loosening the jam nuts and rotating rod until correct length is obtained. Tighten jam nuts.

CHECKING ADJUSTMENT: Align front and rear frame sections. The steering bellcrank should be perpendicular to frame sides and the steering rod at a right angle to the bellcrank.

STEERING BELLCRANK

Inspect the mounting connections in the steering bellcrank for wear and freeness. Pay particular attention to the self-aligning bearing and main pivot bearing. The inner race should move freely and smoothly in the outer race. If the bearings are damaged, loose or rough in movement, press out the bearing. Install new bearings, pressing only on the outer race when installing. Press the outer race centered in the eye. Check that the inner ball moves freely and smoothly in the outer race.

STEERING GEAR ASSEMBLY

REMOVE STEERING GEAR FOR DISASSEMBLY

Refer to steering gear linkage illustration for identification of parts.

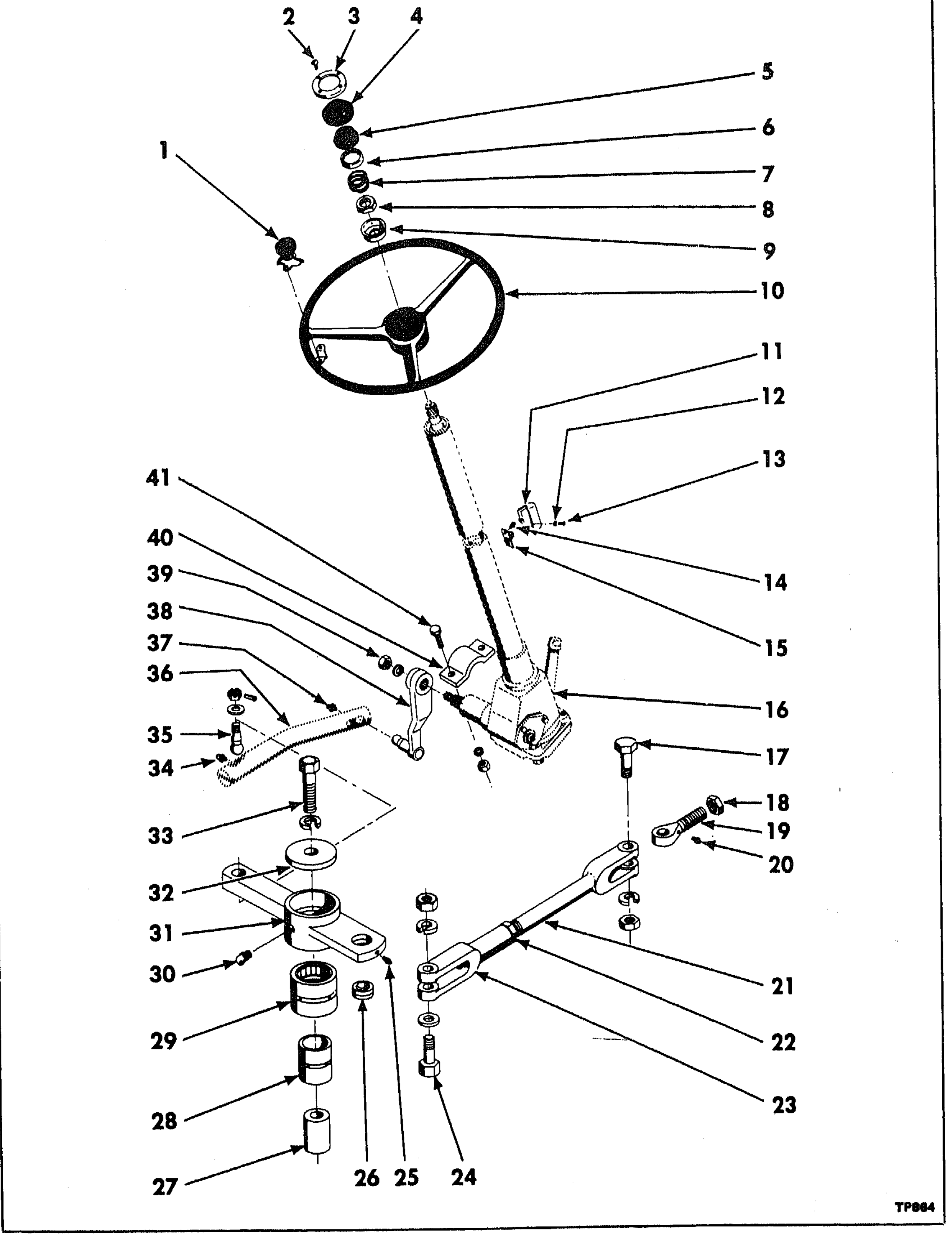
Disconnect the electrical connection to the horn at the junction box on the steering column.

Remove the bracket for the transmission controls from the steering column.

Remove the screws (2); remove the horn button retainer (3), the retaining ring, weather cover (4), horn button (5), insulator (6), spring (7), steering wheel retaining nut (8), and horn contact (9).

Attach a wheel puller and remove the steering wheel (10).

DO NOT HAMMER THE END OF THE SHAFT TO REMOVE WHEEL.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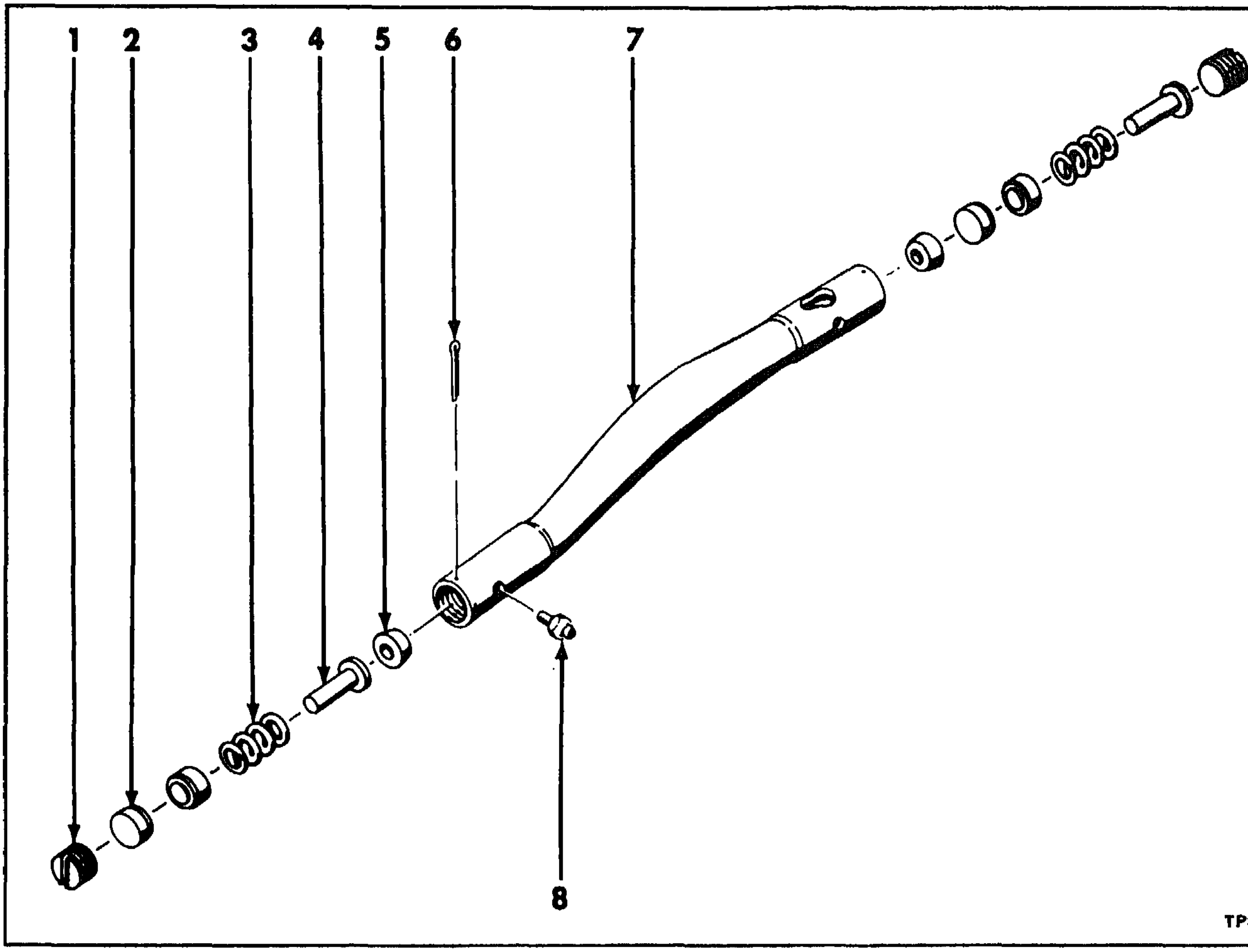
STEERING GEAR ASSEMBLY AND LINKAGE

Part No.	Description	No. Req'd.
2030666	Horn Button Assy. (Incl. Items 2 thru 7 & 9)	1
2034053	Spinner Assy., Steering Wheel	1
2035331	Screw, Plate to Wheel	4
6951367	Retainer, Horn Button	4
6951366	Cover, Weather	1
6951368	Button, Horn	1
6951369	Insulator	1
[illegible]	Spring, Horn Button	1
[illegible]	Nut, Steering Wheel to Column	1
[illegible]	[illegible]	1
[illegible]	[illegible], Steering	1
[illegible]	[illegible]	1
[illegible]	Washer, Lock	2
2035336	Screw, Cover to Column	2
2005886	Screw	2
2005884	Horn Cable Connector Assy.	1
———	Steering Gear Assy. (See Sep. Illus.)	1
[illegible]	Bolt, Rod Assy. to Steer Valve	1
2031393	Washer, Lock	1
[illegible]	Nut	1
[illegible]	Nut, Jam	1
2035686	Washer, Lock (N.I.)	1
2062379	Rod End	1
———	(Not Applicable)	
2060735	Rod Assy., Bellcrank to Steer Valve	1
[illegible]	Nut, Jam	1

Item	Part No.	Description	No. Req'd.
23	2046473	Clevis	1
24	2060737	Bolt, Rod to Bellcrank	1
24A	2036822	Washer, Flat	1
24B	2031396	Washer, Lock	1
24C	2031622	Nut	1
25	2030224	Fitting, Grease	1
26	2060398	Bushing	1
27	2060124	Pin, Bellcrank Pivot	1
28	2059574	Ring, Inner	1
29	2059573	Bearing, Roller	1
30	2033250	Fitting, Grease	1
31	2062111	Bellcrank Assy. (Incl. Items 26, 28 & 29)	1
32	2060118	Lock Plate, Pin	1
33	2031569	Bolt	1
33A	2031395	Washer, Lock	1
34	2030225	Fitting, Grease	1
35	2030647	Stud, Ball	1
35A	2032920	Nut	1
35B	2031769	Pin, Cotter	1
36	2059571	Drag Link, Gear to Bellcrank (See Sep. Ill.)	1
37	2030225	Fitting, Grease	1
38	2038341	Arm, Pitman	1
39	2033520	Nut	1
39A	2031396	Washer, Lock	1
40	2030575	Collar, Split	1
41	2030839	Bolt, Steer Column to Frame	2
41A	2031393	Washer, Lock	2
41B	2031373	Nut	2
42	2033536	Scew, Sq. Hd. Set (N.I.)	2
42A	2031619	Nut (N.I.)	2

[illegible] Parts Included in Service Kit; Order Trojan Part No. 6951090.

(N.I.) Not Illustrated



DRAG LINK

Item	Part No.	Description	No. Req'd.
A	2059571	Drag Link Assy., (Incl. Items 1 thru 8)	1
1	2040222	Plug, Adjusting	2
2	6951365	Seat, Ball	4
3	2040224	Spring	2
4	2040223	Button, Spacer	2
5	2040226	Stop	2
6	2031772	Pin, Cotter	2
7	———	Link, Drag (N.S.S. Order Item A)	1
8	2030225	Fitting, Grease	2

(N.S.S.) Not Serviced Separately

Mark the position of the pitman arm on the pitman shaft gear. Remove nut (39) and lockwasher securing pitman arm to steering gear. Remove pitman arm.

Remove bolts (41), nuts, lockwashers and collar (40) securing steering gear to frame. Remove gear from machine.

STEERING GEAR DISASSEMBLY

Secure the steering gear housing assembly (4) in a vise. Remove the three bolts (14) and lockwashers (13) that attach the housing side cover (12) to the housing. Pry the side cover loose. Turn the lash adjuster (8) clockwise through the cover. Remove the gasket (10), lash adjuster nut (15), lash adjuster, shims (9) and shaft bushing (11).

Turn the steering shaft (21) until the sector gear on the pitman shaft gear will pass through the housing opening and remove the pitman shaft gear from the housing.

Loosen and remove locknut (30) plug (31) with bearing (27). Remove capscrew (29), lockwasher (29A) and bottom cap (28) with gasket (28A) from housing (4). Carefully withdraw the shaft (21) and ball nut (26) as an assembly from the housing (4).

CAUTION: Hold the shaft and ball nut in a horizontal position. If held in a vertical position, the ball nut will travel by its own weight to either end of the shaft threads. If the ball nut strikes either end of the worm sharply, the ball guides will be damaged. If the ball nut is not being disassembled, tape both ends of the shaft worm to prevent ball nut movement.

Check the action of the ball nut on the shaft worm. It must rotate freely with no roughness or binding. If there is evidence of roughness or binding, disassemble it as follows:

1. Remove the bolt and washer assemblies (22) securing ball guide return clamp (23) to the ball nut. Remove the clamp.
2. Pull ball return guides (24) out of the ball nut, one pair at a time and remove balls from return guides by separating the guide halves.
3. Turn ball nut upside down and rotate shaft back and forth until all balls (25) have dropped from ball nut into a clean pan.
4. With all balls removed, slide the ball nut off the shaft.

hazards and insurance regulations, we do not recommend gasoline or any volatile solvent such as naphtha, benzene, etc. Less flammable fluid such as kerosene or mineral spirits should be used. Do not use a caustic solution. After drying thoroughly with clean cloth, lay parts on clean, lint-free surface for inspection. Never use an air hose on or near exposed internal parts because of the presence of water or dirt in the air system.

Clean all parts in solvent before inspecting.

Examine steering gear housing (4) for cracks or stripped threads in cover mounting surfaces. If column is damaged, replace housing assembly.

Check clearance between pitman shaft gear (7) and bushing (35) in housing. If bushing is worn, drive bushing from housing. An improvised tool can be made if desired. Drive new bushing into housing. Again an improvised tool may be made.

Check condition of upper needle bearing (16) in housing. If rollers are damaged or worn, press out bearing. When pressing in new bearing, make sure trade marked side of retainer is against tool.

Check condition of steering column jacket upper bearing assembly (3) and spring (1). Replace if parts are damaged.

Examine side cover (12) for cracks and damage. Check clearance between pitman shaft gear (7) and side cover bushing (11). If bushing is scored, damaged, or excessively worn, it is recommended that side cover and bushing be replaced as an assembly.

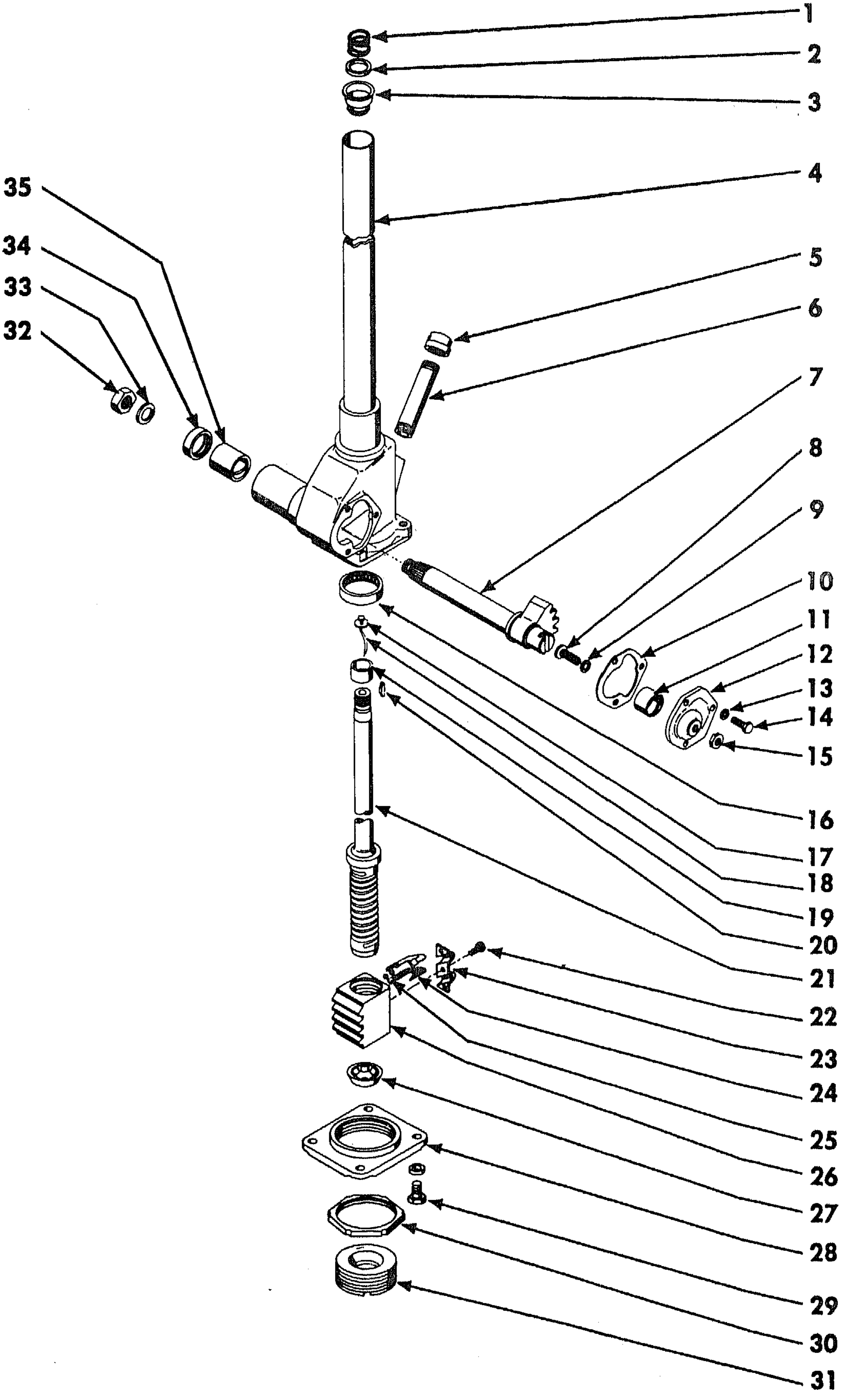
Inspect pitman shaft gear for damaged serration or threads. Examine sector teeth for signs of scuffing or scoring. Check O.D. of shaft. If excessive wear is exhibited at any of these points, replace shaft gear. Grease seal (39) should be removed and replaced if cracked or damaged.

Inspect bearing areas and thread groove on worm of shaft assembly (21).

If worn or galled, replace steering shaft and ball nut (26) complete.

Examine worm ball nut (26) rack teeth for scuffing and scoring. Check holes and passages for obstructions. Check all worm balls (25) for flat spots, checking, wear or damage. Balls should be the same size within 0.0001 inch. Balls must be replaced as complete sets.

Examine ball guides (24) for distortion and bent pick-up fingers. Place two halves of a guide together and try action of balls.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STEERING GEAR ASSEMBLY

Item	Part No.	Description	No. Req'd.
	2052627	Steering Gear Assy.	1
	2005878	Spring, Upper Bearing	1
	2005882	Washer, Upper Bearing	1
	2005880	Upper Bearing Assembly	1
	6951357	Housing Assy. (Incl Items 16 & 35)	1
	2005892	Cap	1
	2005894	Pipe, Filler	1
	2005930	Gear, Pitman Shaft	1
	2005936	Adjuster, Lash	1
	2005940	Shim Kit, Lash Adjuster	1
	2005932	Gasket, Housing Side Cover	1
	2005968	Bushing, Pitman Shaft	1
	2005934	Cover Assy. (Incl. Item 11)	1
	2031391	Washer, Lock	3
	2031473	Bolt, Side Cover	3
	2031372	Nut, Lash Adjuster	1
	2005956	Bearing, Needle	1
	2035352	Terminal Assy., Horn	1
	2035351	Cable, Horn	1

Item	Part No.	Description	No. Req'd.
19	2035350	Contact Assy. (Incl. Item 18)	1
20	2005876	Key, Steering Wheel	1
21	6951364	Shaft Assy. (Incl. Items 17 thru 19 & 22 thru 26)	1
22	2035353	Bolt & Washer Assy.	3
23	2005960	Clamp, Ball Return Guide	1
24	2005958	Guide, Ball Return	4
25	2005962	Ball	106
26	2005964	Nut, Ball	1
27	6951361	Bearing, Worm Thrust	1
28	6951360	Cover, Housing End	1
28A	2005896	Gasket, End Cover (N.I.)	1
29	2031497	Bolt, End Cover	4
29A	2031392	Washer, Lock	4
30	6951363	Nut, Lock Bearing Adjuster	1
31	6951362	Adjuster, Thrust Bearing	1
32	2005924	Nut, Pitman Arm	1
33	2005926	Washer, Lock Pitman	1
34	2005928	Seal, Pitman Shaft	1
35	2005966	Bushing, Pitman Shaft	1

.I.) Not Illustrated

STEERING GEAR REASSEMBLY

One of the most important phases of assembling steering gear components is cleanliness. All parts must be kept clean. Any bits of abrasive material which may get inside of the housing during assembly will quickly damage the mechanism. Grease and oil used at assembly must be free from dirt. Prelubricate all bearings and moving parts with lubriplate.

Refer to the steering gear illustration for parts identification.

Place steering shaft assembly flat on bench. Place ball nut (26) over worm on shaft assembly (21) with ball return guide holes in ball nut in upper surface. Align groove in worm and ball nut by sight.

Count one-half, 53, of the total quantity, 106 of balls (25) into a clean container.

Drop balls into one of the ball return guide holes in the upper circuit.

Gradually turn worm away from that hole while inserting balls. Continue until the circuit is filled from the bottom of one hole to the bottom of the other, or until stopped by reaching end of worm.

In the event balls are stopped by reaching the end of worm, hold down the balls already inserted with a rod or punch. Turn shaft a few turns in the reverse direction. Filling of the circuit can then be continued.

It may be necessary to work shaft back and forth, holding balls down, first in one hole, then in the other. This will close up spaces between balls, filling the circuit completely.

Lay one-half of ball guide (24), with groove up, on bench. Place the remaining balls selected into groove of guide. Close this half. Hold the two halves together; then plug each end with heavy chassis grease to prevent balls from dropping out.

Push ball return guide completely into holes in ball nut. This completes one circuit of balls.

Fill lower circuit in ball nut in same manner.

Install ball return guide clamp (23) on ball nut. Tighten bolts and washers (22) securely.

Make certain ball nut and balls are thoroughly lubricated. Test assembly by rotating ball nut on worm. Do not rotate ball nut to end of worm threads. Assembly must move freely. Temporarily tape shaft at both ends of ball nut until ready to install assembly into steering gear housing.

Remove tape. Grip worm below and above the ball nut to prevent nut from running to extreme ends. Insert steering shaft assembly (21) through lower opening in gear housing (4) and guide shaft carefully through the upper column needle bearing (16).

Place original lash adjuster screw shim (9) on lash adjuster (8). Insert adjuster and shim into slotted end of pitman shaft gear (7).

Check clearance between adjuster head and shaft sl
end. Clearance must not exceed 0.0002 inch. If clea
ance is greater, select a thicker shim. Four sizes a
available.

Insert pitman shaft gear into housing; turn gear
sector will go in housing. Mesh sector with ball n
inside housing.

Turn steering shaft until ball nut is in approxima
center of shaft worm. Center tooth of pitman sha
must enter center tooth space of ball nut.

With lash adjuster and shim in place in slotted end
pitman shaft gear and with new side cover gasket
place on side cover, start side cover (12) over end
shaft. Insert screwdriver into hole in side cover to e
gage slot in adjuster.

Turn lash adjuster to pull cover over end of shaft. Ba
off adjuster to permit lash between sector and ball n

Install side cover lockwashers (14) and bolts (13
tighten to 15-20 lb. ft. torque.

Install bottom cover (28), gasket (28A) with capscre
(29) and lockwasher (29A). Insert bearing (27)
plug (31) and install plug (31) in bottom of cover (28
Secure with locknut (30).

With gear on center, adjust pitman shaft adjuster
that the pull on an 18-inch diameter wheel is 1¼ to
pounds through a 20-degree arc over center. Tight
nut (15). Total pull on the 18-inch wheel for all adju
ments should be 1⅛ to 2 pounds over center. Tight
nut (15) to 20-30 lb. ft. torque when adjustment
correct.

STEERING GEAR INSTALLATION

Refer to the Steering Gear Linkage illustration for par
identification.

Position the steering wheel (10), contact (9), and n
(8) on shaft. Tighten steering wheel nut securely.

Position the steering gear in the machine. Position t
collar (40) over the steering gear arm; secure to t
frame with bolts (41), lockwashers, and nuts.

Position the pitman arm (38) on the splines of t
pitman shaft gear, matching the marks made at disa
sembly. NOTE: The pitman arm should be position
on the pitman shaft gear in an approximate vertical po
tion. Center tooth of pitman shaft must enter cent
tooth of ball nut. Secure with a lockwasher and nut (39

Move the drag link (36) toward the pitman arm a
engage the ball stud (35) in the link. Secure with
cotter pin and castle nut.

Connect the horn wiring to the box at the side of t
steering column.

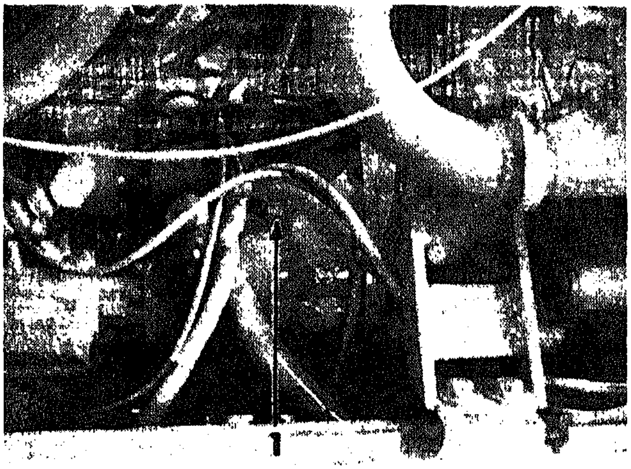
Install the spring (7), insulator (3), horn button (5
and weather cover (4). Align the holes in the weath
cover with the holes in the steering wheel.

Position the retainer (3) over the weather cover a
secure with screws (2).

Install the bracket for the transmission controls on t
steering column.

Lubricate the steering gear as shown in the Lubricati
section.

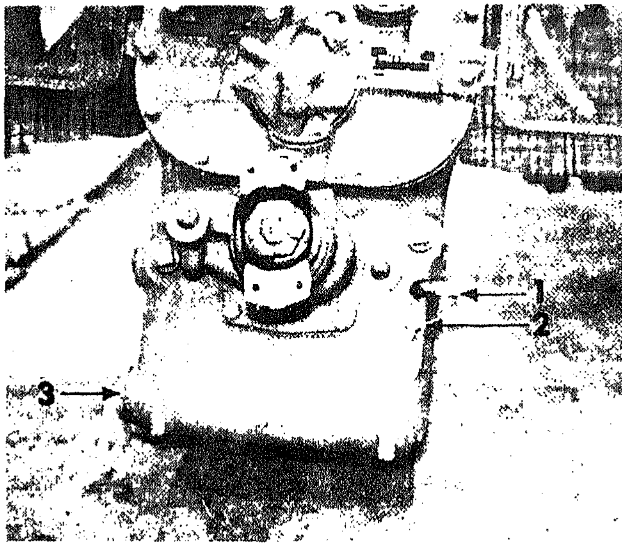
In the event the transmission does not function properly, check the hydraulic oil supply immediately at the level plugs (See Fig. 24). Make up oil should be added through the fill plug located on the left side of the torque converter (See Fig. 23). Thoroughly inspect all hoses, lines and fittings for leaks. Replace any found to be defective.



1. Plug

Fig. 23. Converter Fill Plug

Before attempting any maintenance or repair on the transmission or torque converter, consult the transmission and converter section in this manual. Trouble-shooting table and oil check procedures may also be found there.



1. High Oil Level Check
2. Correct Oil Level Check
3. Transmission Drain

Fig. 24. Transmission Oil Level Check and Drain

TRANSMISSION AND TORQUE CONVERTER SYSTEM

The torque converter and transmission are hydraulically interconnected with hoses through which the circulation of the transmission hydraulic fluid is directed. The fluid is also directed through a filter which removes any particles which could damage the highly machined mechanical parts of the transmission and torque converter. An oil cooler which is integral with the radiator is also connected into the transmission and torque converter piping to maintain the hydraulic fluid at the proper operating temperature. The high pressure necessary for the operation of the transmission clutches is supplied by the converter charging hydraulic pump mounted on the torque converter. It also supplies the lower pressure to charge the torque converter. The pressure is regulated by a regulator assembly mounted on the converter.

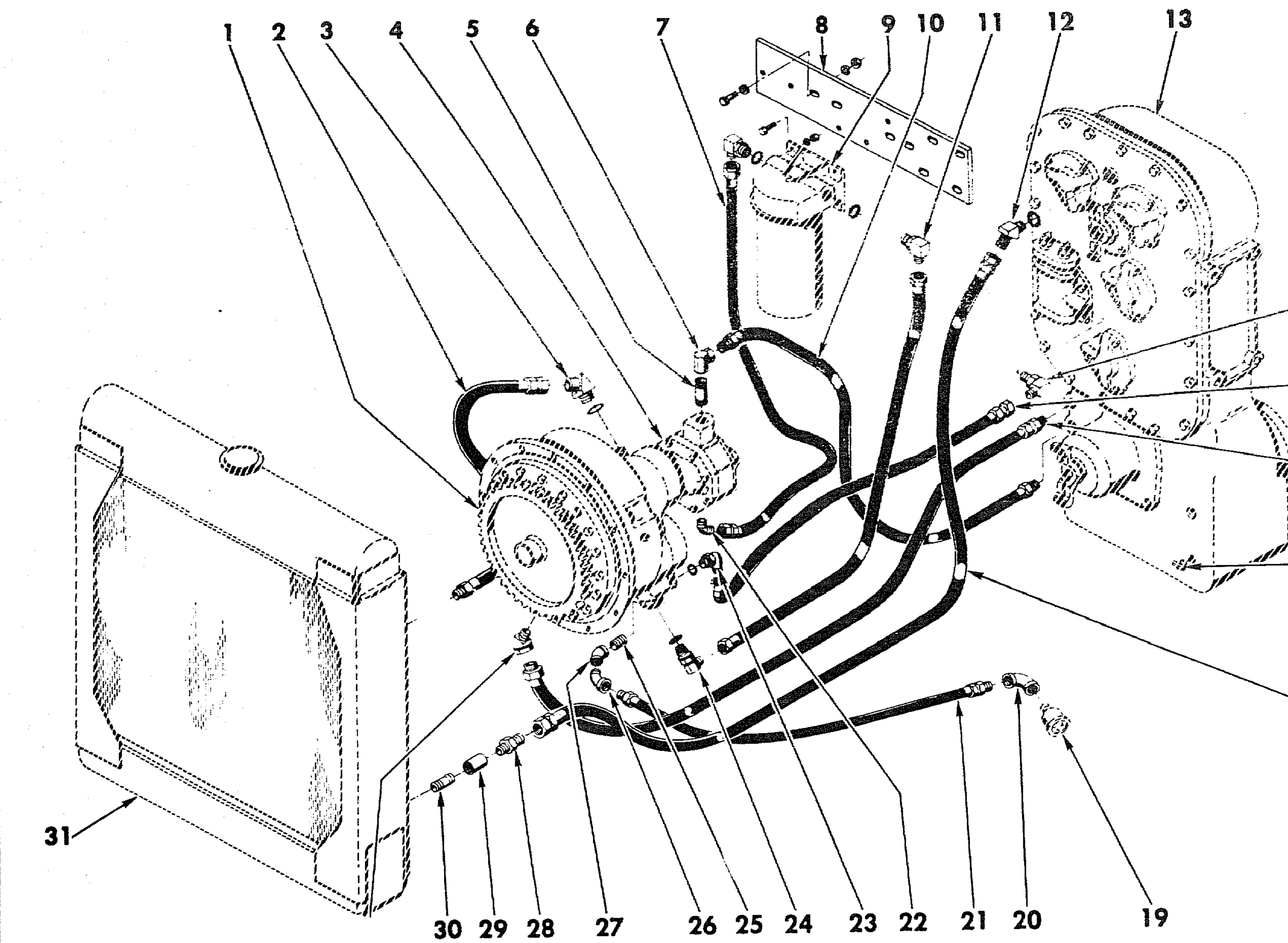
TORQUE CONVERTER AND TRANSMISSION PRESSURE CHECKS

To determine the operating efficiency of the torque converter and transmission, it is necessary to make pressure checks at various points in the system. If pressures deviate from the required pressures, the cause of the incorrect pressure must be located and corrected immediately before major damage to the transmission or torque converter occurs.

NOTE: All hydraulic pressure checks must be made with the hydraulic fluid at operating temperature (200°F. minimum).

Converter clutch pressure. Check the converter clutch pressure at the converter pressure regulator valve located on the lower side of the converter slightly to the right of the centerline of the machine. With the engine stopped, remove the plug (6). (Refer to the Pressure Regulator Valve illustration for prats identification. Insert a 0 to 500 psi hydraulic pressure gauge in the port. With the direction shift and speed shift levers in NEUTRAL, accelerate the engine to 2000 rpm and check pressure. Pressure should be 240 to 280 psi.

Converter OUT pressure. With the engine stopped, remove the plug from the port to which the elbow (5) and the radiator to converter hose (4) are connected. (Refer to Transmission Hydraulic System illustration TP 1051 for parts identification. Install a 0 to 100 psi hydraulic pressure gauge into the port. Start the engine and accelerate it to 2000 rpm.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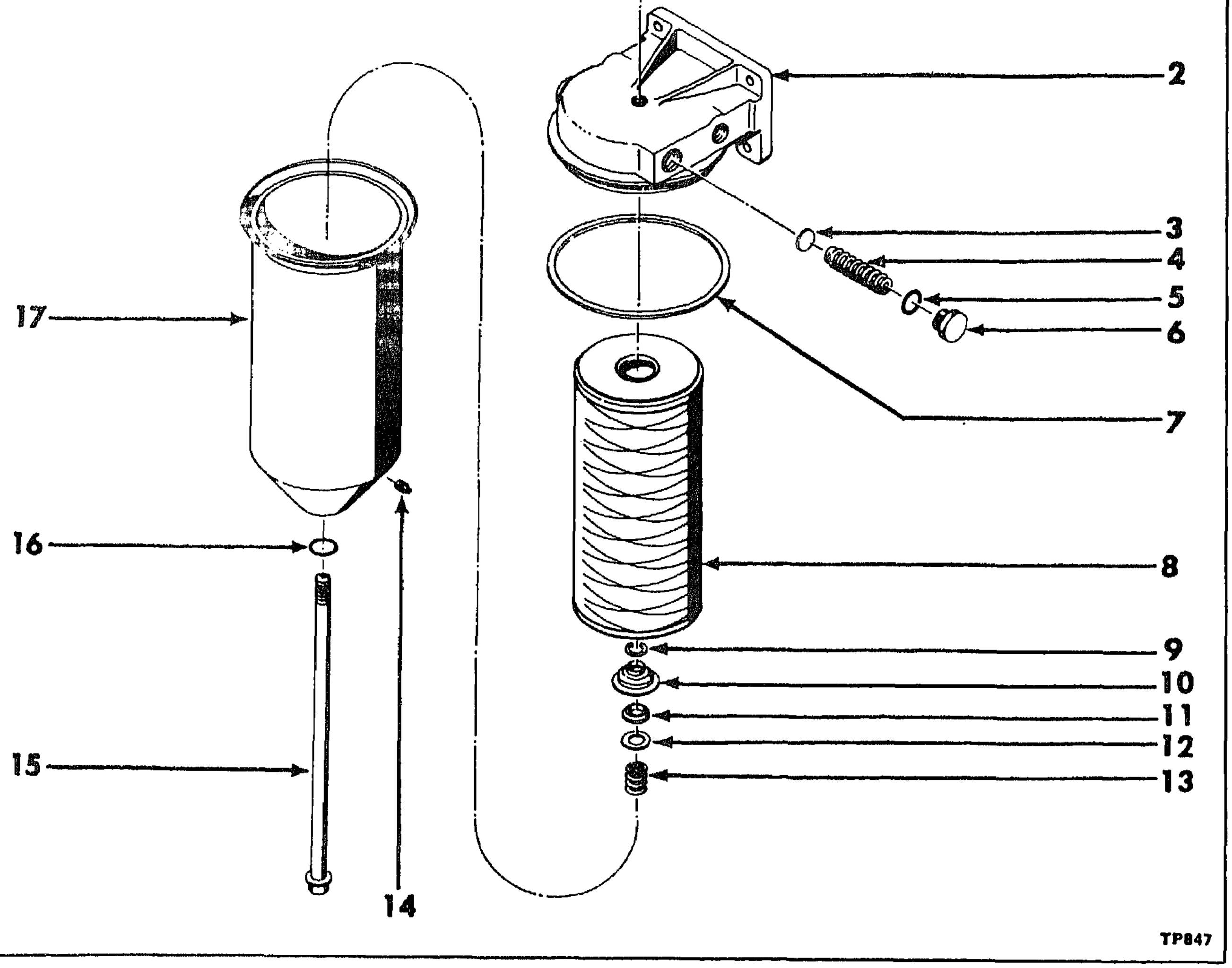
TRANSMISSION HYDRAULIC SYSTEM

Item	Part No.	Description	No. Req'd.
1	———	Converter, Torque (See Sep. Illus.)	
2	2067670	Hose	1
2A	6951986	End, Hose	2
3	2058556	Elbow, Adapter, 45° (Incl. Item 3A)	1
3A	2031961	"O" Ring	1
4	———	Pump (See Sep. Illus.)	
5	2034914	Nipple	1
6	2002794	Adapter, 90° Union	1
7	2068084	Hose	2
7A	6951995	End, Hose	4
8	2067862	Plate, Mount	1
8A	2031477	Bolt	4
8B	2032960	Washer, Flat	4
8C	2031391	Washer, Lock	4
8D	2031617	Nut	4
9	———	Filter (See Sep. Illus.)	
9A	2031479	Bolt	4
9B	2032960	Washer, Flat	4
9C	2031391	Washer, Lock	4
9D	2031617	Nut	4
10	2067667	Hose	1
10A	6951984	End, Hose	2
11	2031927	Elbow, 90° (Incl. Item 11A)	2
11A	2031961	"O" Ring	2
12	2058556	Elbow, Adapter, 45° (Incl. Item 12A)	1
12A	2031961	"O" Ring	1
13	———	Transmission (See Sep. Illus.)	
14	2031925	Elbow, 90° (Incl. Item 14A)	1
14A	2031959	"O" Ring	1
15	2067672	Hose	1
15A	6951997	End, Hose	2
16	2067668	Hose	1
16A	6951985	End, Hose	2
17	2033212	Cock, Drain	2
18	2068050	Hose	1
18A	6951989	End, Hose	2
19	———	Gauge, Clutch Pressure (See Instrument Panel)	
20	2032274	Elbow, 90°	1
21	2067669	Hose	1
21A	6952000	End, Hose	2
22	2032001	Elbow, Adapter, 45°	1
23	2031925	Elbow, 90° (Incl. Item 23A)	1
23A	2031959	"O" Ring	1
24	2031927	Elbow, 90° (Incl. Item 24A)	1
24A	2031961	"O" Ring	1
25	2039440	Nipple	1
26	2032283	Elbow, Pipe, 45°	1
27	2032301	Elbow, 45°	1
28	2031992	Adapter, Straight	1
29	2033087	Coupling	2
30	2033644	Nipple, R.H.	2
31	———	Radiator (See Engine & Related Parts)	

(N.I.) Not Illustrated



TRANSMISSION OIL FILTER ASSEMBLY

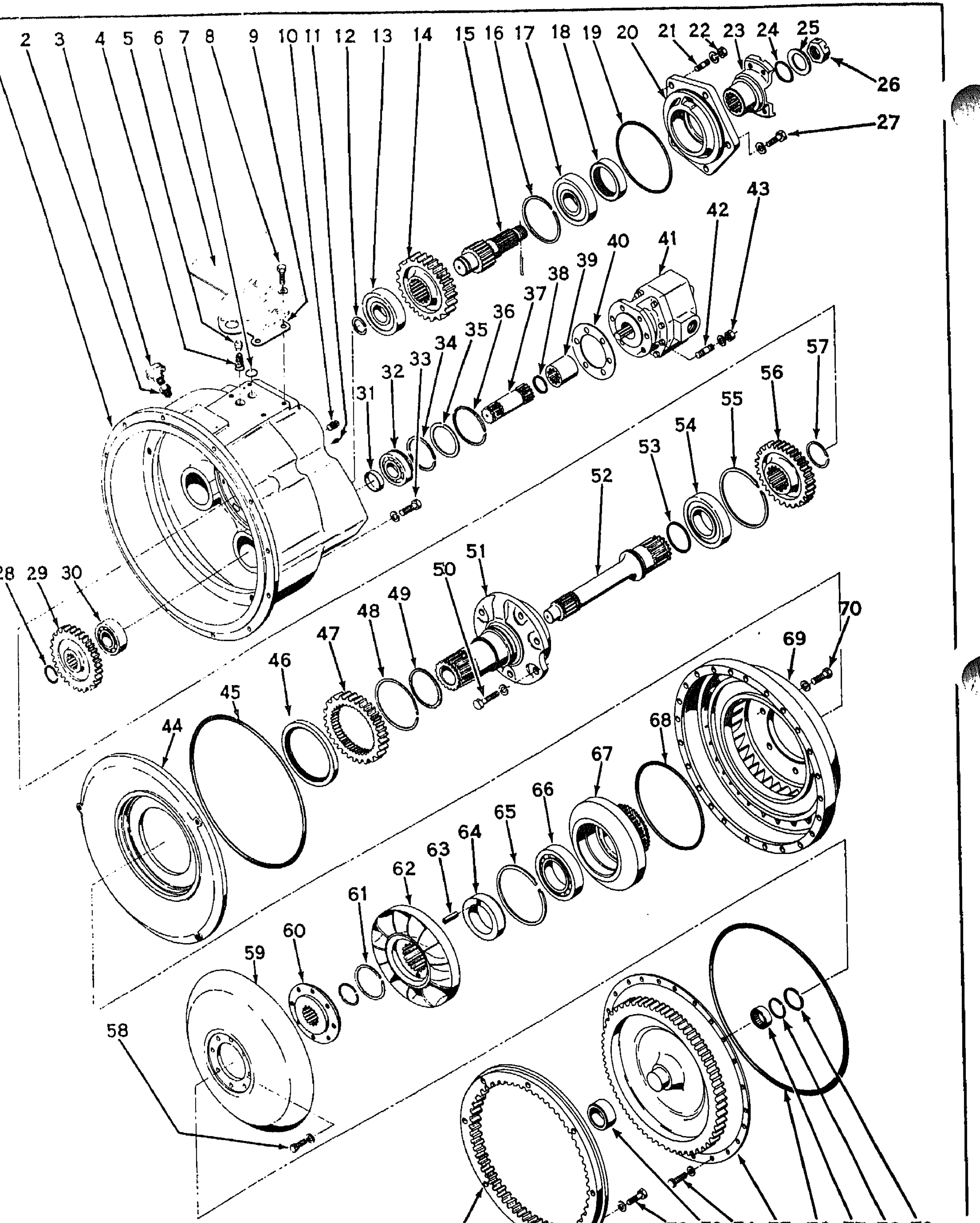
em	Part No.	Description	No. Req'd.
A	2060028	Oil Filter Assy. (Incl. Items 1 thru 17)	1
B	6955207	Element & Gasket Kit (Incl. Items 7 & 8)	1
1	6951384	Plug	1
2	6951383	Head	1
3	6951387	Disc	1
4	6951479	Spring	1
5	6951397	"O" Ring	1
6	6951385	Plug	1
7	6951389	Gasket Seal	1
8	6951388	Element Assy.	1

Item	Part No.	Description	No. Req'd.
9	6952008	Ring, Snap	1
10	6951396	Support, Cartridge	1
11	6951394	Seal, Bolt	1
12	6951395	Washer, Bolt Seal	1
13	6951392	Spring Cartridge	1
14	2033384	Plug	1
15	6951398	Bolt, Shell Retainer	1
16	6951480	Washer, Copper	1
17	6951391	Shell, Sub-Assy.	1
18	6951390	Shell Assy. (Incl. Items 9 thru 13 & 15 thru 17)	1

.I.) Not Illustrated

TROUBLE SHOOTING THE TORQUE CONVERTER

TROUBLE	PROBABLE CAUSE	REMEDY
Low converter down-stream pressure (below 20 psi with engine at 2000 rpm—no load)	Worn oil sealing and "O" rings.	Trouble is internal and will require a complete teartown of the converter.
	Worn oil pump.	Replace.
	Safety valve remains open.	Clean and check valve spring and valve.
Suction line taking air	Low oil level.	Fill to proper level.
	Suction line connections taking air.	Check oil line connections and tighten securely.
	Worn oil pump.	Replace.
High converter downstream pressure (above 45 psi with engine at 2000 rpm—no load)	Oil cooler or oil lines restricted.	Check oil cooler line and oil cooler for restrictions. Clean or replace.
	Oil too heavy.	Check oil weight. See oil recommendations.
	Cold oil.	Converter pressure in cold weather will vary. As soon as converter gets hot, pressure should drop.
Overheating	Oil cooler or oil cooler lines restricted, causing safety valve to stay open.	Clean and check oil cooler and oil cooler lines. Replace if necessary.
	Oil cooler too small.	Replace with larger cooler.
	Worn oil pump.	Replace oil pump.
	Converter drain line to transmission or oil sump not installed properly.	Install at lowest drain opening in converter housing. Line must maintain constant gradual drop to oil sump for gravity drain.
Noisy converter	Worn coupling gear.	Replace.
	Worn oil pump.	Replace.
	Damaged bearing.	A complete teardown will be necessary to determine. Replace if necessary.
	Worn drive gears.	Replace.
Low clutch pressure	Transmission malfunction	Close pressure line to transmission control valve. If clutch pressure returns to normal, trouble in transmission.
	Worn oil pump.	Replace.
	Regulation valve stuck open.	Clean and check valve for worn or dirty parts; replace if necessary.
High clutch pressure	Regulation valve stuck closed.	Clean and check valve for worn or dirty parts; replace if necessary.
Lack of power	Improper engine function.	Tune engine.
	Engine stall speed below normal.	Tune engine. Check governor.
	Improper oil.	See capacities (transmission hydraulic system).
Oil in engine flywheel housing	"O" ring between impeller cover and impeller damaged.	Replace.
	[illegible]	[illegible]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TORQUE CONVERTER ASSEMBLY

Item	Part No.	Description	No. Req'd.
A	2055577	Converter Assy., Torque (Incl. Items 1 thru 83)	1
1	6900837	Housing, Converter	1
2	6950649	Valve Assy., Check	1
3	6950169	Breather	1
4	2039282	Spring, Safety Valve	1
5	2039281	Plunger, Safety Valve	1
6	———	Valve Assy., Pressure Regulating (See Sep. Illus.)	1
7	2039221	"O" Ring	1
8	2031475	Screw, Valve to Converter	2
8A	2031391	Washer, Lock	2
9	2039284	Gasket	1
10	2033383	Plug, Pipe	1
11	2033386	Plug, Pipe	1
12	6900836	Ring, Retaining	1
13	6900805	Bearing, Output Shaft Front	1
14	6900789	Gear, Output Shaft	1
15	6900787	Shaft, Output	1
16	6900788	Ring, Retaining	1
17	2039344	Bearing, Output Shaft Rear	1
18	2039297	Seal, Oil	1
19	2039222	"O" Ring	1
20	6900783	Retainer & Seal Assy. (Incl. Item 18)	1
21	2039287	Stud, Retainer	2
22	2033516	Nut	2
22A	2031392	Washer, Lock	2
23	2022477	Flange, Output	1
24	2035400	"O" Ring	1
25	2039300	Washer, Output Shaft	1
26	2039301	Nut, Output Shaft	1
26A	2031771	Pin, Cotter	1
27	2031498	Bolt, Retainer	3
27A	2031392	Washer, Lock	3
28	2039316	Ring, Retaining	3
29	2039315	Gear, Pump Drive	3
30	6950117	Bearing, Pump Shaft Front	3
31	6950118	Spacer, Pump Shaft	3
32	2039311	Bearing, Pump Shaft Rear	3
33	2031480	Bolt, Oil Baffle	3
33A	2031391	Washer, Lock	3
34	2039310	Ring, Retaining	3
35	2039309	Washer, Pump Shaft	3
36	2039308	Ring, Retaining	3
37	2039304	Shaft, Pump Drive	3
38	2039312	Ring, Retaining	3
39	2039307	Sleeve, Pump Drive Adapter	1
40	2039306	Gasket	2
41	6900782	Pump Assy., Converter Charging	1
41A	6900798	Adapter, Pump (N.I.)	1

Item	Part No.	Description	N
41B	2033268	Gasket (N.I.)	
41C	2031475	Bolt (N.I.)	
41D	2031391	Washer, Lock (N.I.)	
41E	2035557	Stud (N.I.)	
42	2039305	Stud, Pump	
43	2033515	Nut	
43A	2031391	Washer, Lock	
44	2039318	Baffle, Oil	
45	2039270	"O" Ring	
46	2039278	Seal, Oil	
47	2039279	Gear, Impeller Hub	
48	2039292	Ring, Sealing	
49	2039290	Ring, Retaining	
50	2031519	Screw, Stator Support	
50A	2039403	Washer, Lock	
51	2039302	Support & Sleeve, Assy. Stator	
52	6900781	Shaft, Turbine	
53	2039293	Ring, Sealing	
54	2039295	Bearing	
55	2039275	Ring, Retaining	
56	6900786	Gear, Turbine Shaft	
57	6900785	Ring, Retaining	
58	2039322	Screw, Turbine Hub	
58A	2039321	Washer	
59	2022475	Turbine	
60	2039323	Hub, Turbine	
61	2039263	Ring, Retaining	
62	2022476	Reaction Member	
63	2039271	Pin	
64	2039274	Spacer	
65	2039275	Ring, Retaining	
66	6950167	Bearing, Hub	
67	2022474	Hub	
68	2039410	"O" Ring	
69	2022473	Impeller	
70	2030811	Bolt, Hub	
70A	2039277	Washer, Lock	
71	2039266	Gear Assy., Ring (Incl. Items 72 & 72A)	
72	2039267	Bolt, Ring Gear to Flywheel	
72A	6950168	Washer	
73	2039325	Sleeve, Impeller Cover	
74	2031475	Screw, Cover	
74A	2031391	Washer, Lock	
75	2039265	Cover, Impeller	
76	2039270	"O" Ring	
77	2039261	Bearing, Cover	
78	2039324	Ring, Retaining	
79	2039262	Ring, Retaining	
80	2033389	Plug, Pipe (N.I.)	
81	2033388	Plug, Pipe (N.I.)	
82	6900829	Plate, Identification (N.I.)	
83	2039273	Screw (N.I.)	

N.I. Not Illustrated

Check the converter OUT pressure on the gauge. It must be between 25 and 40 psi. Transmission clutch pressure. With a 0 to 500 psi pressure gauge connected as directed for the converter clutch pressure check described above, start the engine and allow it to run at idle speed (400 to 600 rpm). Shift the transmission direction and speed range levers in the following positions and check the clutch pressure readings on the gauge:

FORWARD AND LOW
FORWARD AND HIGH
REVERSE AND LOW
REVERSE AND HIGH

Minimum oil pressure at any of these settings must be 240 psi.

TORQUE CONVERTER DISASSEMBLY

To remove the torque converter, it is necessary to remove the assembled converter and engine. Thoroughly clean the area of the engine around the torque converter before removing the converter to prevent entry of dirt into the converter. Support the converter and remove the bolts that secure the converter to the engine. Pull straight out on the converter to free it from the engine. The following procedure describes the disassemby of the torque converter when it is removed from the vehicle for complete overhaul.

CAUTION: Cleanliness is of extreme importance and an absolute must in the repair and overhaul of the converter. Before attempting any repairs, the exterior of the unit must be thoroughly cleaned to prevent the possibility of dirt and foreign matter entering the mechanism.

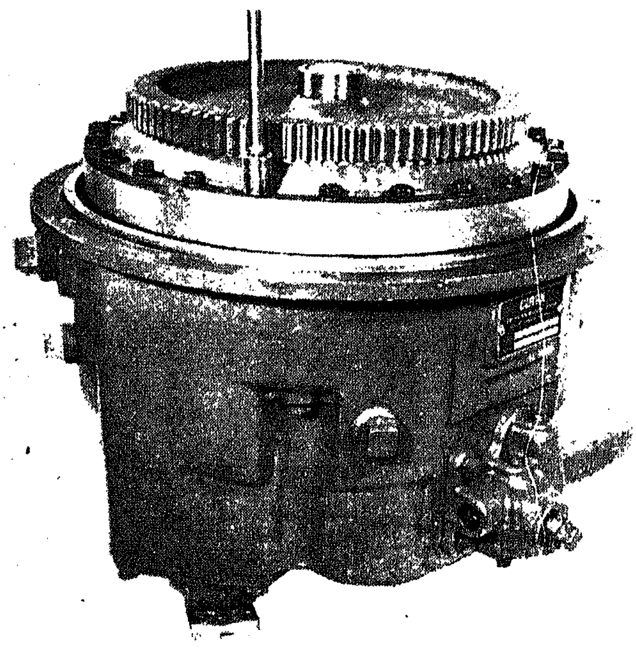


Fig. 25

Remove bolts securing impeller cover to impeller (Fig. 25.

Use two bolts in threaded puller holes 180 degrees apart to remove imueller cover from impeller (Fig. 26).

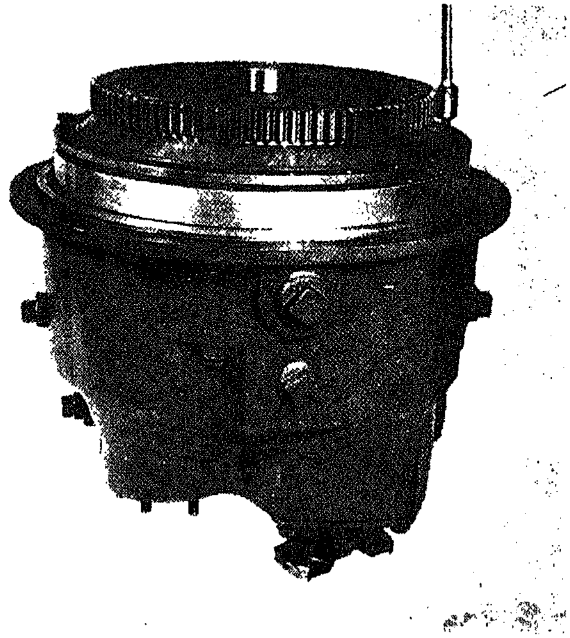


Fig. 26

If pilot bushing sleeve is to be replaced, use procedure shown in Fig. 27.

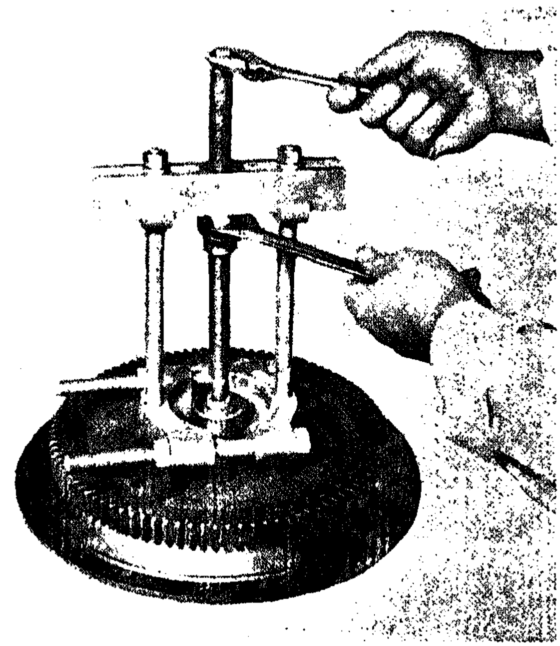


Fig. 27

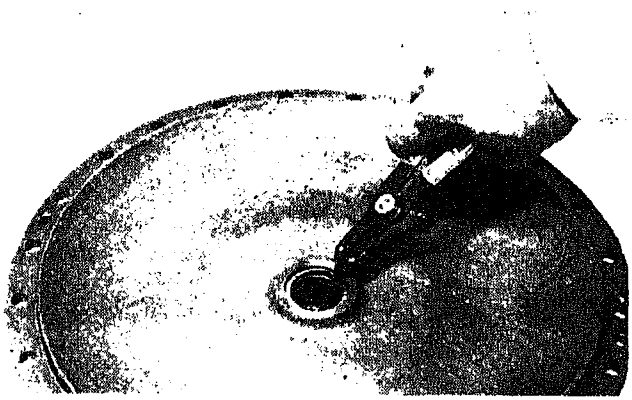


Fig. 28

Remove outer turbine hub retainer ring (Fig. 29).

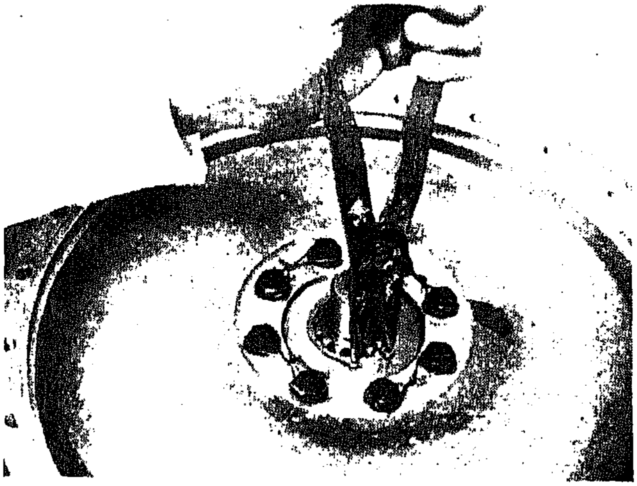


Fig. 29

Remove turbine and hub assembly from turbine shaft.

Remove turbine locating ring (Fig. 30).

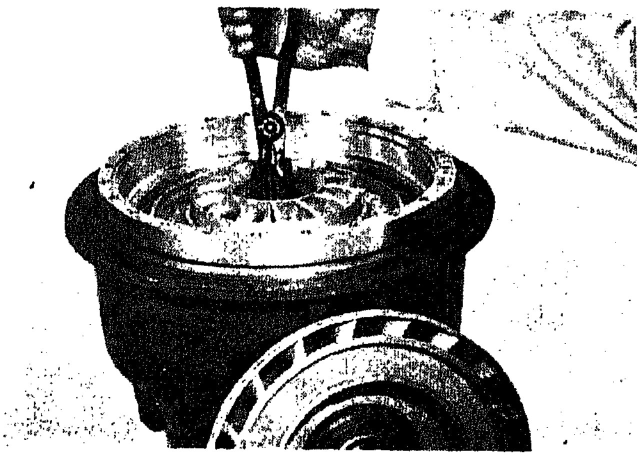


Fig. 30

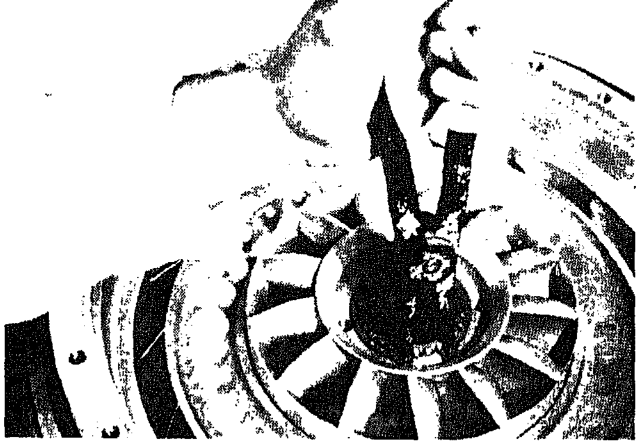


Fig. 31

Remove reaction member from stator support; threaded puller holes are provided should reaction member be too tight to be removed by hand (Fig. 32).

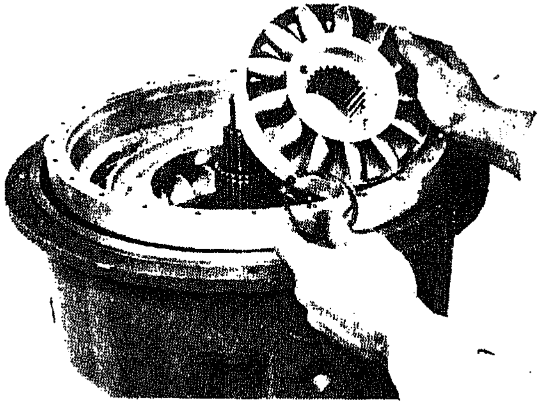


Fig. 32

Reaction member spacer is held to reaction member by a roll pin; replace if damaged (Fig. 33).

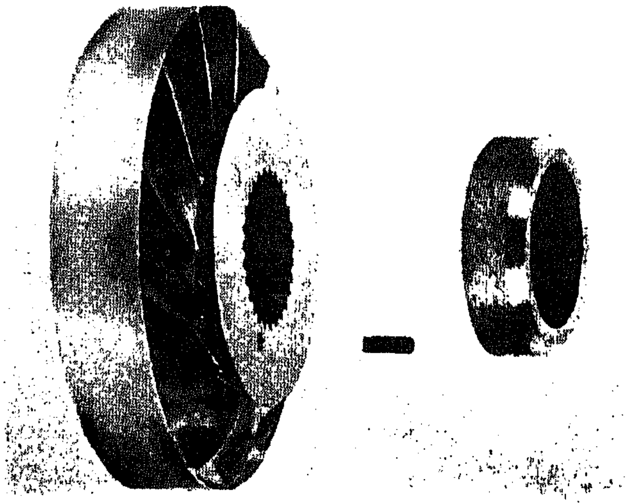


Fig. 33

Remove three bolts that secure oil baffle to converter housing (Fig. 34).

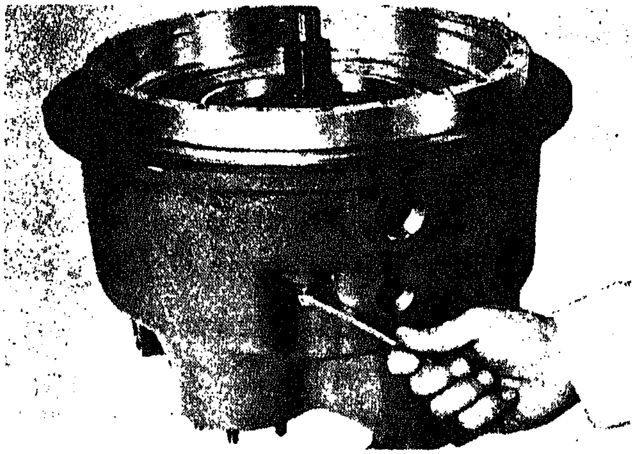


Fig. 34

Install special puller tool as shown in Fig. 35; turn jack screw, pulling oil baffle and impeller from stator support as an assembly. Special tool can be made for easier removal of impeller assembly, but is not necessary (Fig. 36).

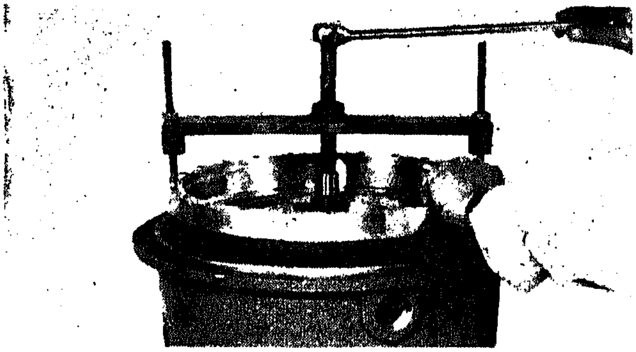


Fig. 35

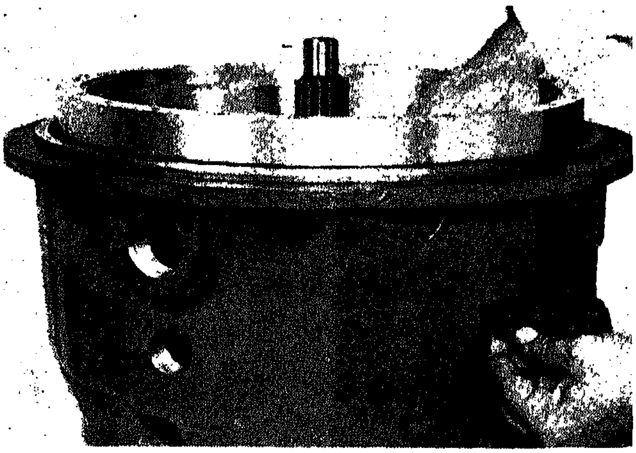


Fig. 36

If special tool is not available, remove oil baffle bolt part way. Tap lightly on each bolt; this will loosen oi baffle from converter housing; remove oil baffle and impeller from housing as an assembly (Fig. 36).

Remove impeller hub gear retainer (Fig 37).

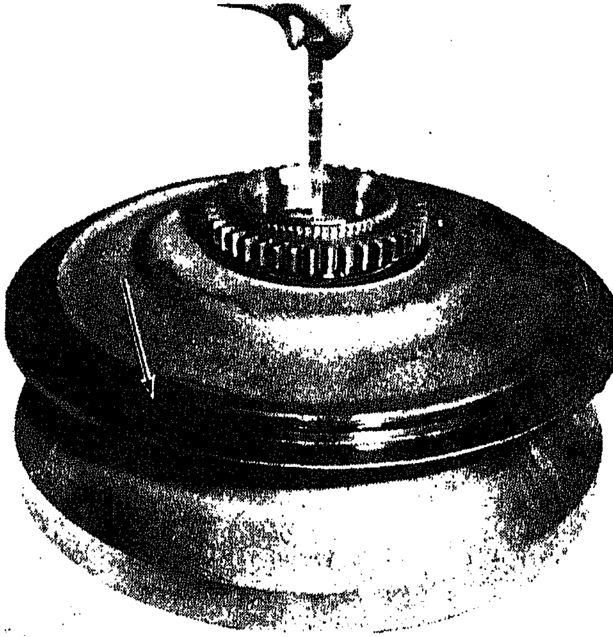


Fig. 37

Remove impeller hub gear and oil baffle from impeller (Fig. 38).

NOTE: Oil seal should be removed only if it is to be replaced.

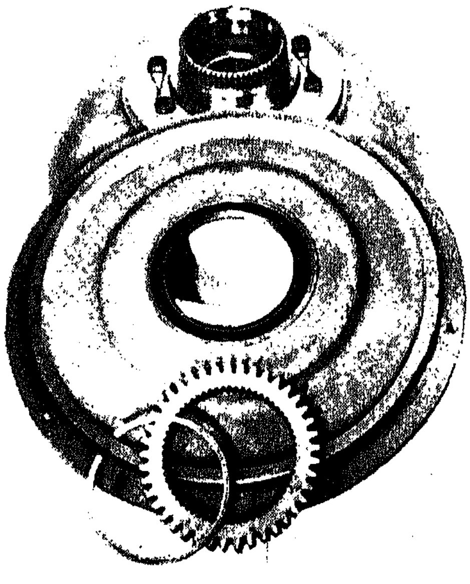


Fig. 38

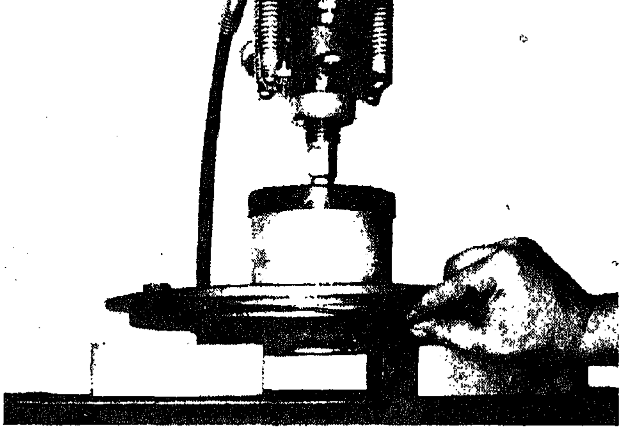


Fig. 39

Remove impeller hub bolt lockwire and hub bolts (Fig. 40).

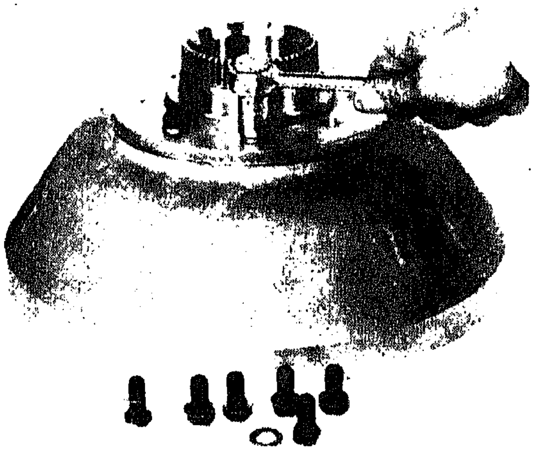


Fig. 40

Remove impeller hub from impeller. Remove hub "O" ring (Fig. 41).

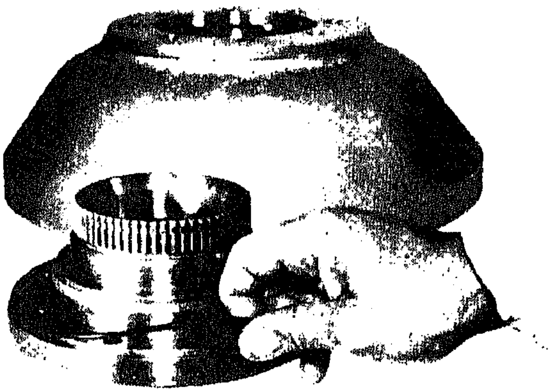


Fig. 41

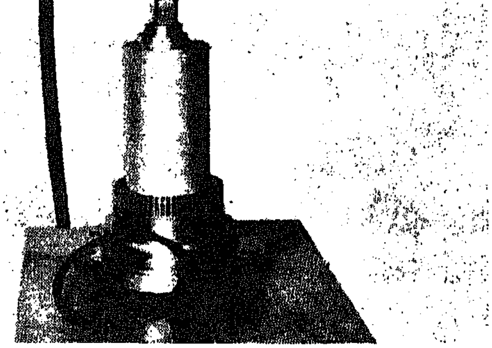


Fig. 42

Three pump drives are installed on the converter. Disassembly is similar for the three drives.

Remove oil pump drive gear retaining rings. Remove drive gears from pump shafts (Fig. 43).

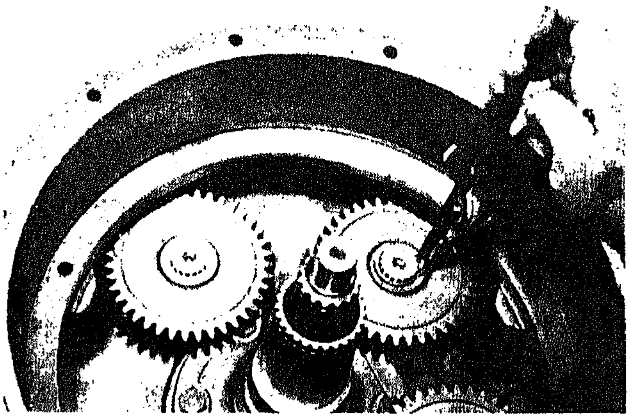


Fig. 43

Remove stator support bolts (Fig. 44).

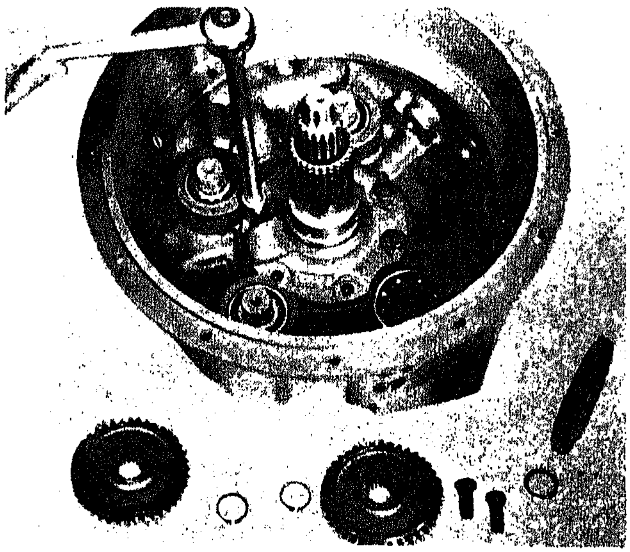


Fig. 44

Remove stator support and turbine shaft assembly from converter housing (Fig. 45).

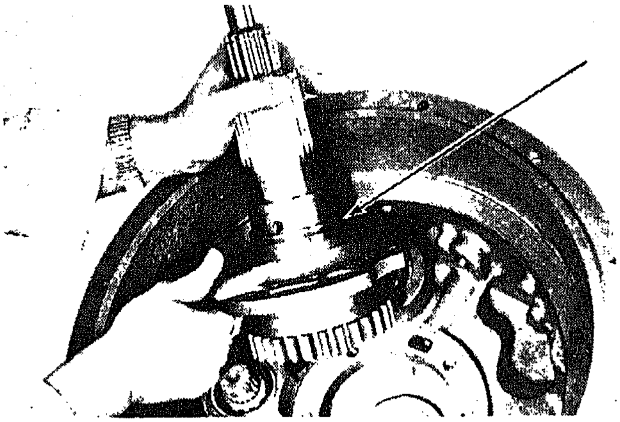


Fig. 45

Remove turbine shaft gear retainer ring and turbine shaft gear (Fig. 46).

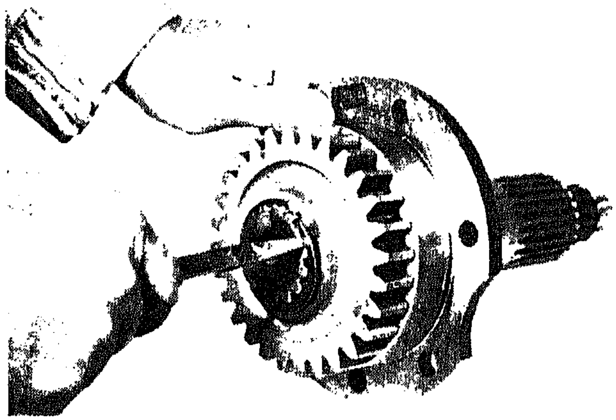


Fig. 46

Remove turbine shaft bearing retainer ring from stator support (Fig. 47).

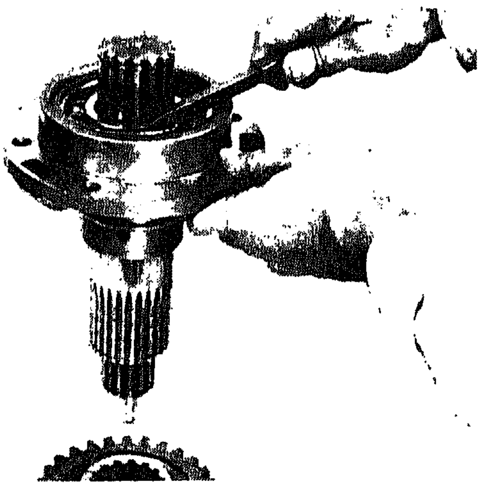


Fig. 47

Press turbine shaft from stator support ... bearing from turbine shaft. Remove oil sealing rings from stator support and turbine shaft (Fig. 48).

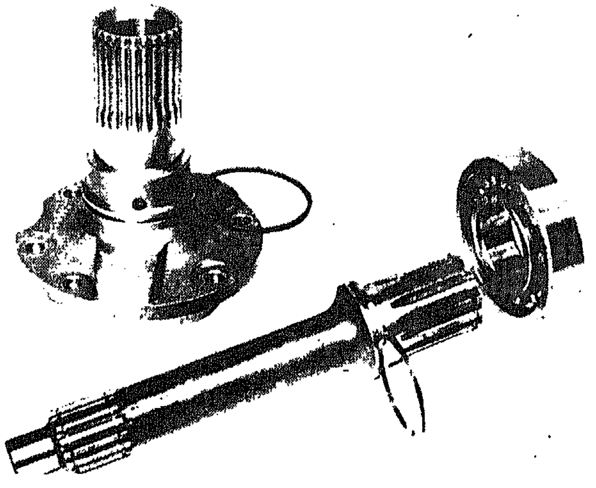


Fig. 48

Remove pump adapter sleeve from pump shaft. Remove pump shaft washer retainer ring and pump shaft washer (Fig. 49).

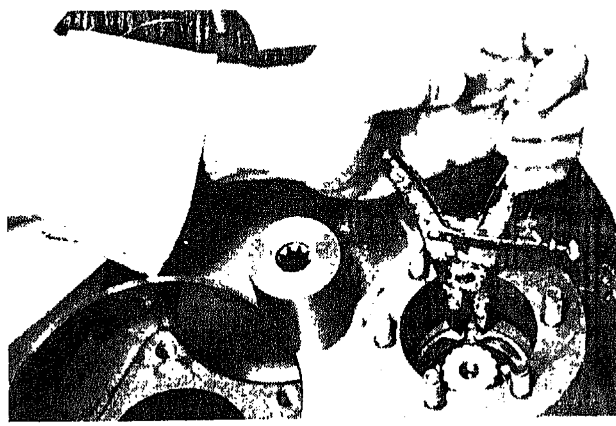


Fig. 49

Tap on pump shaft from inside converter housing pump shaft and bearings will come out as an assembly (Fig. 50).

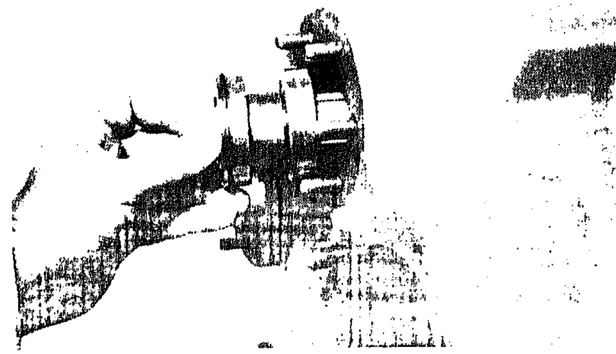


Fig. 50

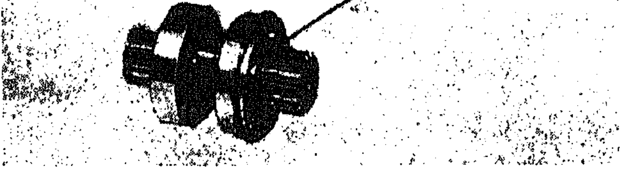


Fig. 51

Remove pressure regulator valve assembly (Fig. 52).

Use caution as not to lose safety valve plunger or spring. (See arrow.)

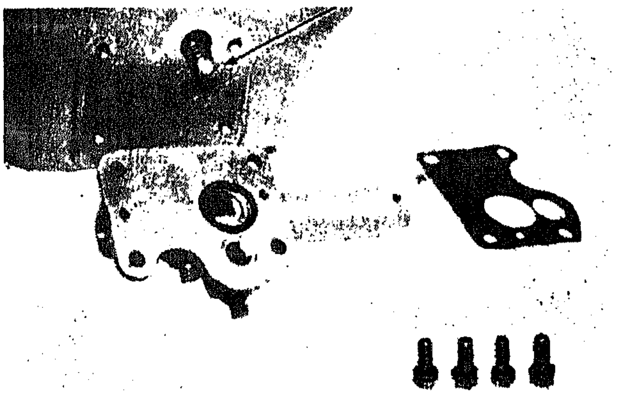


Fig. 52

Depress piston stop and remove piston stop roll pin.

Remove piston stop and inner and outer spring. Remove roll pin at opposite end. Remove valve stop and valve piston (Fig. 53).

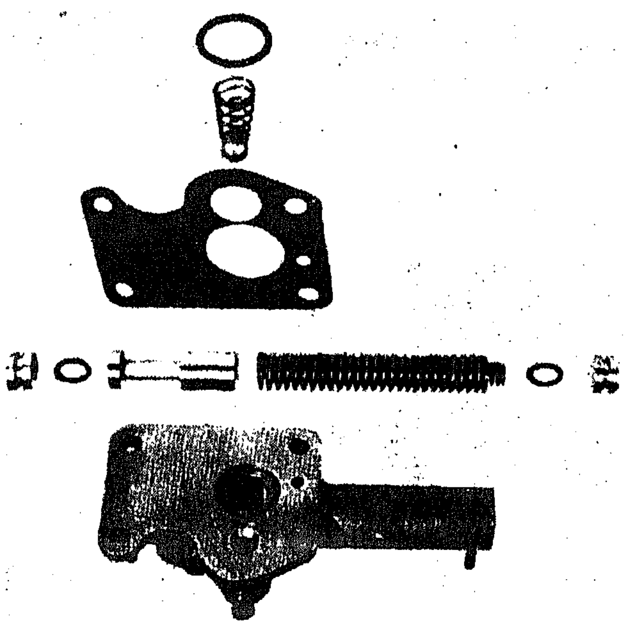


Fig. 53

Cleanliness of the respective parts is absolutely neces-sary in reassembling. Dirt in its many forms can and will cause trouble. Therefore, when reassembling the converter or any of its parts, be sure all parts have been thoroughly cleaned with a suitable cleaning fluid. After cleaning, dry all parts with moisture-free, compressed air.

A thorough visual examination of all parts should be made before reassembly. Replace any parts that show excessive wear or damage. Small nicks or burrs may be removed with a hone or crocus cloth. It is recommended that all gaskets, oil seals, piston sealing rings, "O" rings and internal lockwashers be replaced.

A light coat of Permatex No. 2, applied to the outer diameter of oil seals, ensures a good oil tight fit between oil seal and housing. The use of grease is recommended when positioning new gaskets in their respective locations. Coat piston sealing rings and "O" rings with type "A" Automatic Transmission Fluid to facilitate assembly.

TORQUE CONVERTER REASSEMBLY

Install valve piston (Fig. 54). Install valve sop and new "O" ring in valve housing and secure with roll pin.

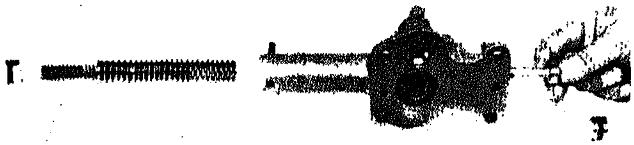


Fig. 54

Install inner and outer valve spring in valve housing (Fig. 55). Install valve spring stop and new "O" ring in valve housing. Depress spring stop and install spring stop roll pin.

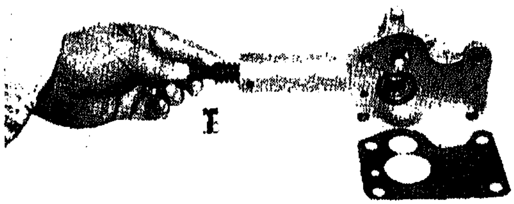


Fig. 55

Install pump shaft rear bearing locating ring. Press rear bearing on pump shaft with bearing snap ring toward rear of shaft. Install bearing spacer and press front bearing on shaft until it shoulders against bearing spacer (Fig. 56).

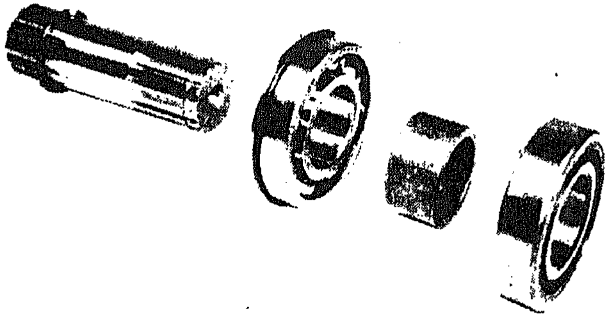


Fig. 56

Install pump shaft and bearing assembly in converter housing (Fig. 57).

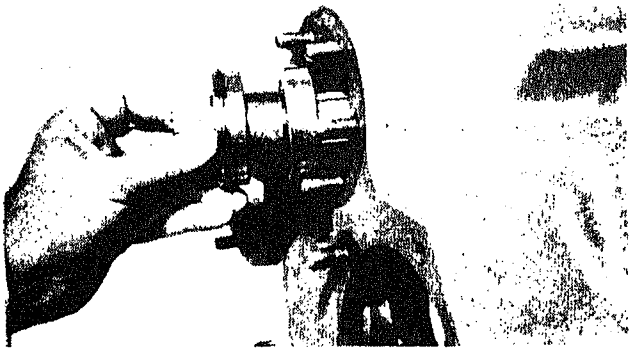


Fig. 57

Tap pump shaft and bearing assembly in converter housing until rear bearing snap ring shoulders against bearing bore (Fig. 58).

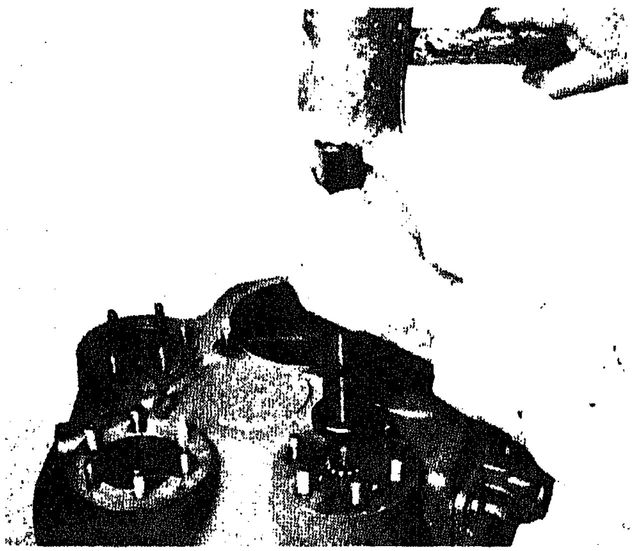


Fig. 58

Install pump shaft washer and washer retainer ring

Pump adapter sleeve can be installed just before pump installation (Fig. 59).

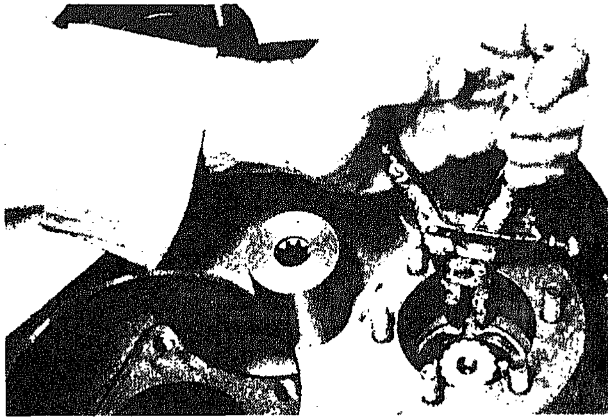


Fig. 59

Press output shaft oil seal in bearing retainer, lip of seal in (Fig. 60).

NOTE: Oil seal must be pressed 5/16 inch below rear face of bearing retainer. Press rear output shaft bearing in bearing retainer and secure with retainer ring.

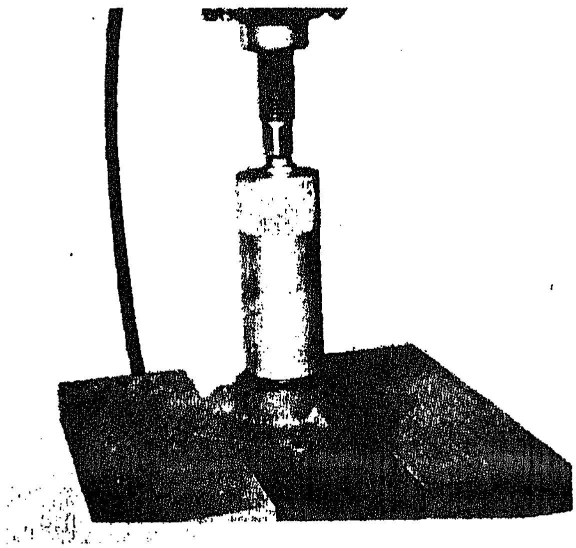


Fig. 60

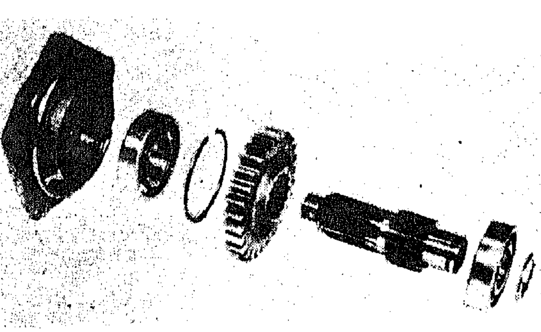


Fig. 61

Press output shaft, gear, and bearing assembly through rear bearing and bearing retainer (Fig. 62). Secure output shaft gear in vise equipped with soft jaws. Install companion flange, new flange "O" ring, flange washer, and flange nut; tighten nut 200 to 250 lb. ft. torque.

Install nut cotter.

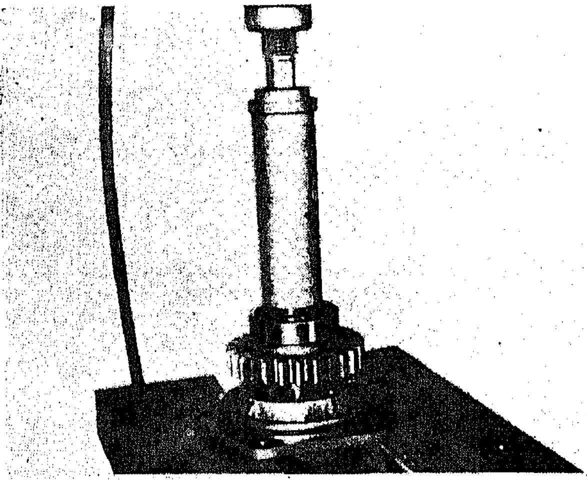


Fig. 62

Install new "O" ring (see arrow) on output shaft bearing retainer. Install output shaft assembly to converter housing and secure with nuts, bolts and lockwasher; tighten 35 to 40 lb. ft. torque (Fig. 63).

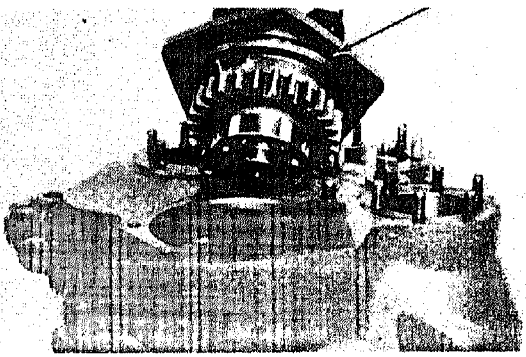


Fig. 63

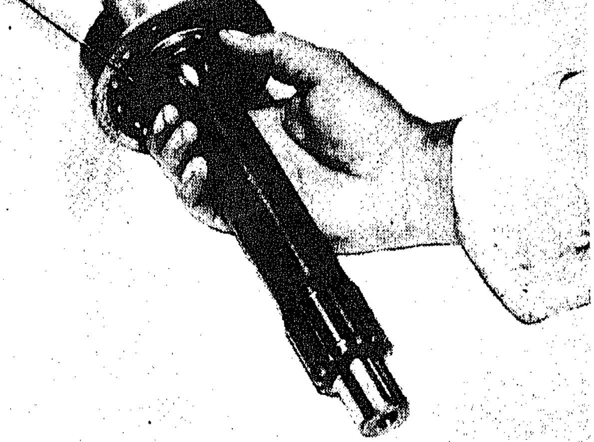


Fig. 64

Press shaft and bearing assembly in stator support. Use caution as not to damage oil sealing ring. Secure bearing with retainer ring (Fig. 65).

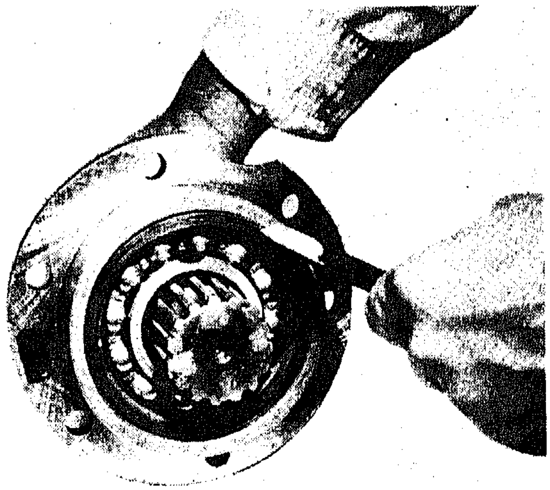


Fig. 65

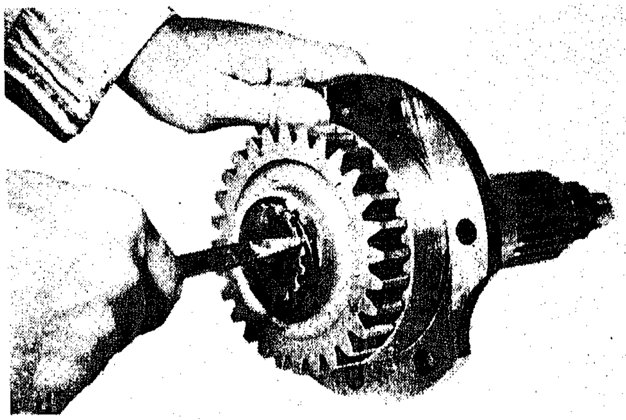


Fig. 65

Install turbine shaft gear on turbine shaft and secure with retainer ring (Fig. 66).

Install oil sealing ring (see arrow) on stator support (Fig. 67).

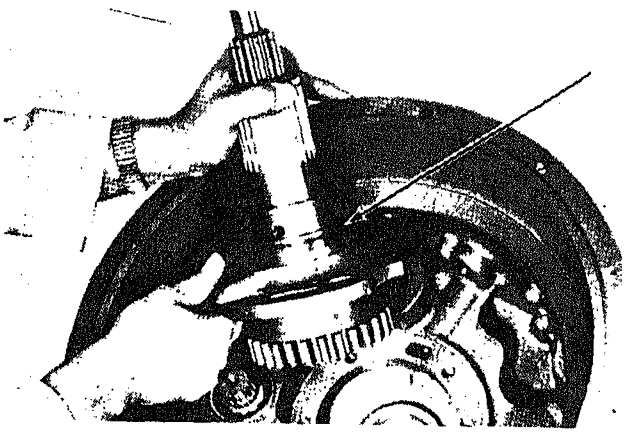


Fig. 67

Align holes in stator support with holes in converter housing. Install bolts and tighten 45 to 50 lb. ft. torque. Lockwire bolts in pairs to prevent loosening (Fig. 68).

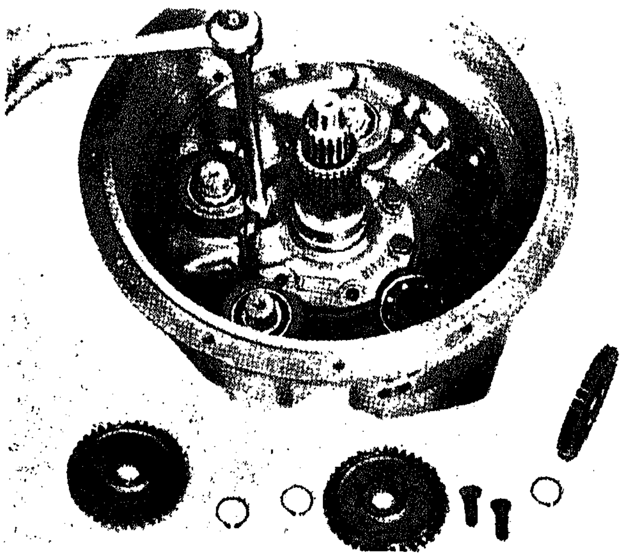


Fig. 68

Install oil pump drive gears and secure with retaine rings (Fig. 69).

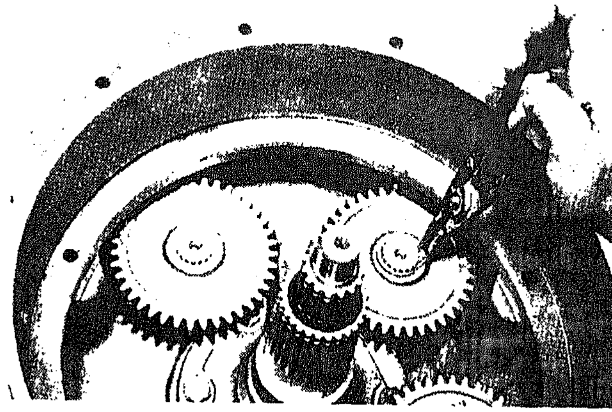


Fig. 69

Press new oil seal in oil baffle with lip of seal down (Fig 70).

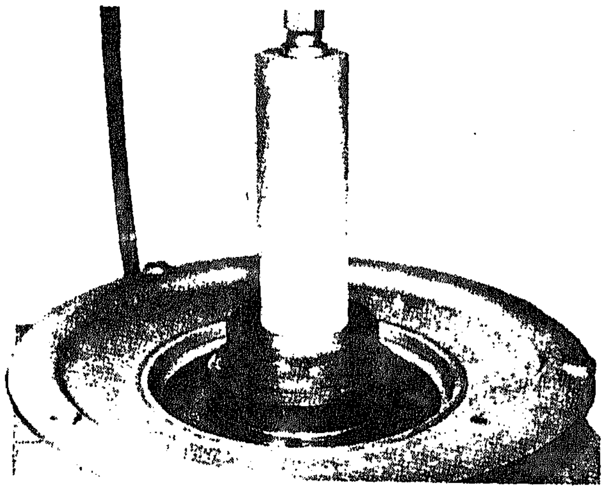
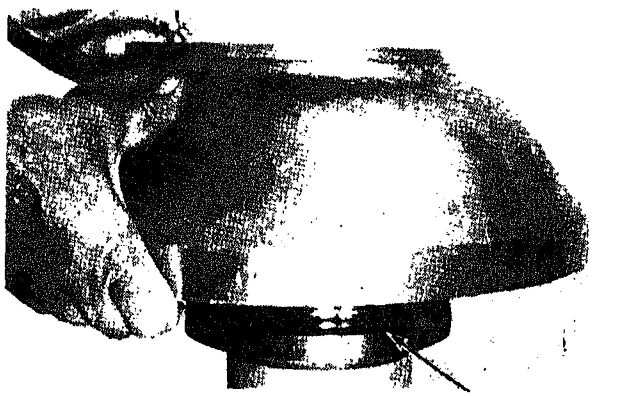


Fig. 70



ft. torque. Lockwire bolts in pairs to prevent loosening.

Install oil baffle or impeller assembly. Install impeller hub gear on impeller hub and secure with retainer ring.

Install new "O" ring on oil baffle (see arrow) (Fig. 72).

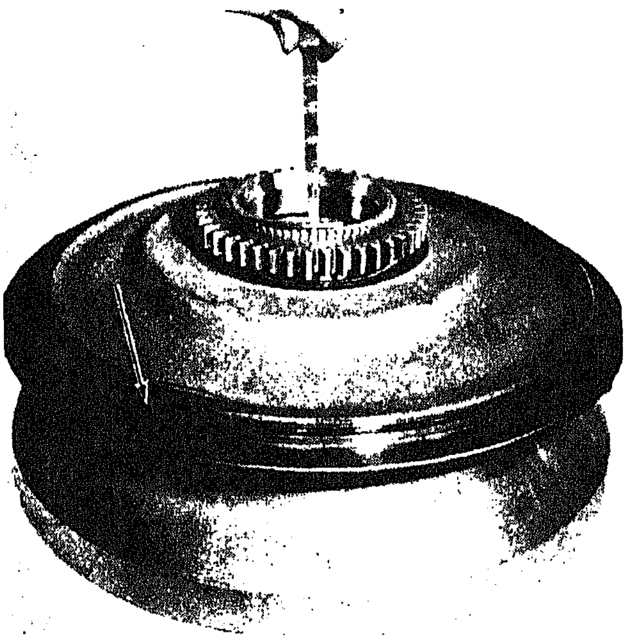


Fig. 72

Install impeller and oil baffle assembly over stator support and into converter housing. Align holes in oil baffle with holes in converter housing. Install bolts and lockwashers into oil baffle (Fig. 73). Tighten baffle bolts evenly to prevent damaging oil baffle "O" ring. Tighten 20 to 25 lb. ft. torque.

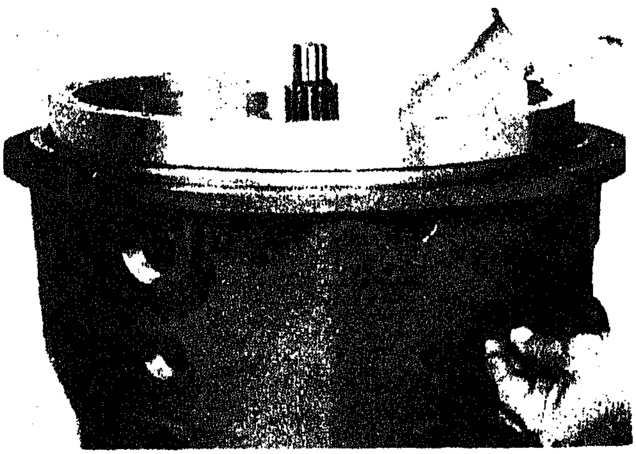


Fig. 73

Fig. 74

Install reaction member on stator support and secure with retaining ring (75).

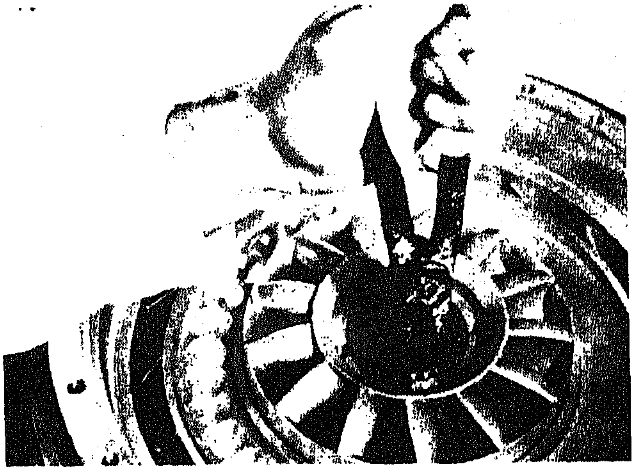


Fig. 75

Install inner turbine locating ring on turbine shaft (Fig. 76).

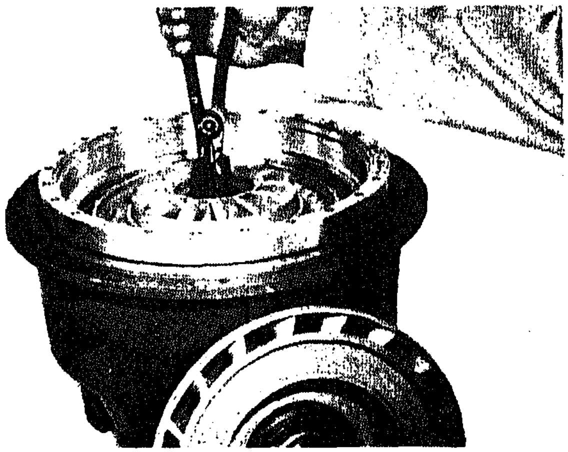


Fig. 76

Install turbine and hub assembly on turbine shaft and secure with outer retaining ring (Fig. 77).

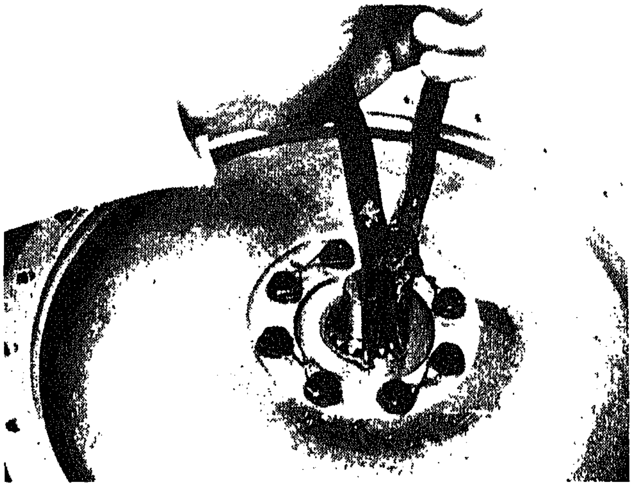


Fig. 77

Press pilot bearing in impeller cover and secure with retainer ring (Fig. 78).

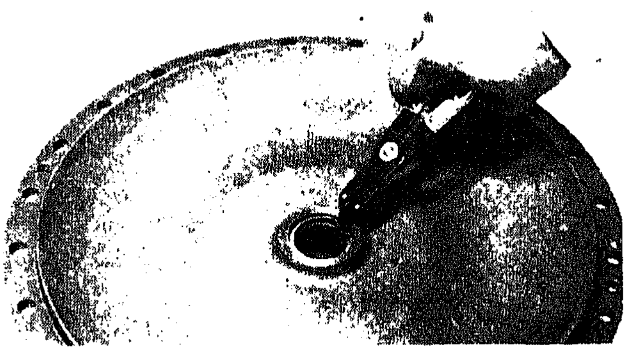


Fig. 78

Heat impeller cover sleeve to 200 degrees and press on impeller cover.

Install spring and plunger in converter housing (see arrow). Install new gasket on valve assembly. Install new "O" ring on valve assembly (Fig. 79). Secure valve assembly to converter housing with bolts and lockwash- ers. Tighten 20 to 25 lb. ft. torque.

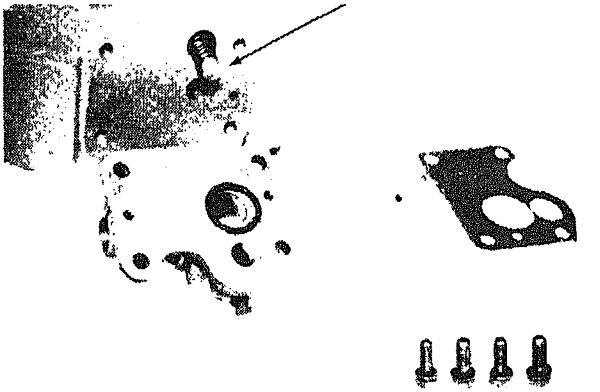


Fig. 79

Install new "O" ring (see arrow) on impeller cove Align holes in impeller cover with holes in impelle (Fig. 80).

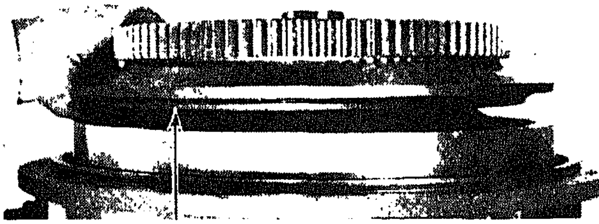


Fig. 80

Install impeller cover to impeller bolts and lockwashe and tighten 20 to 25 lb. ft. torque. (Fig. 81).

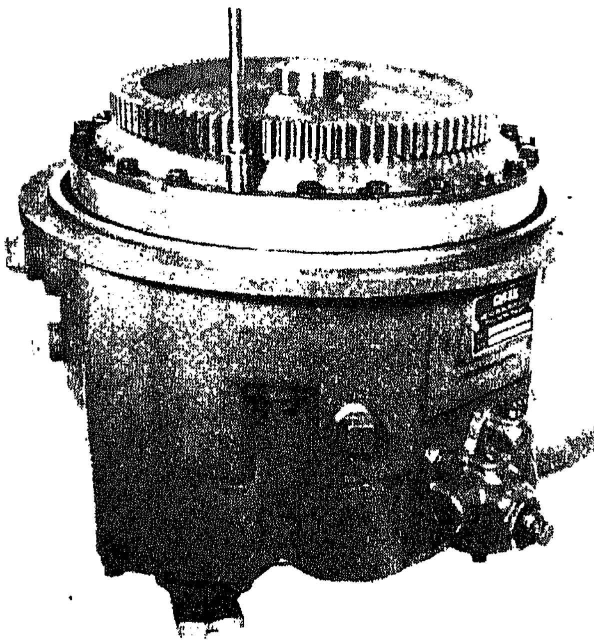
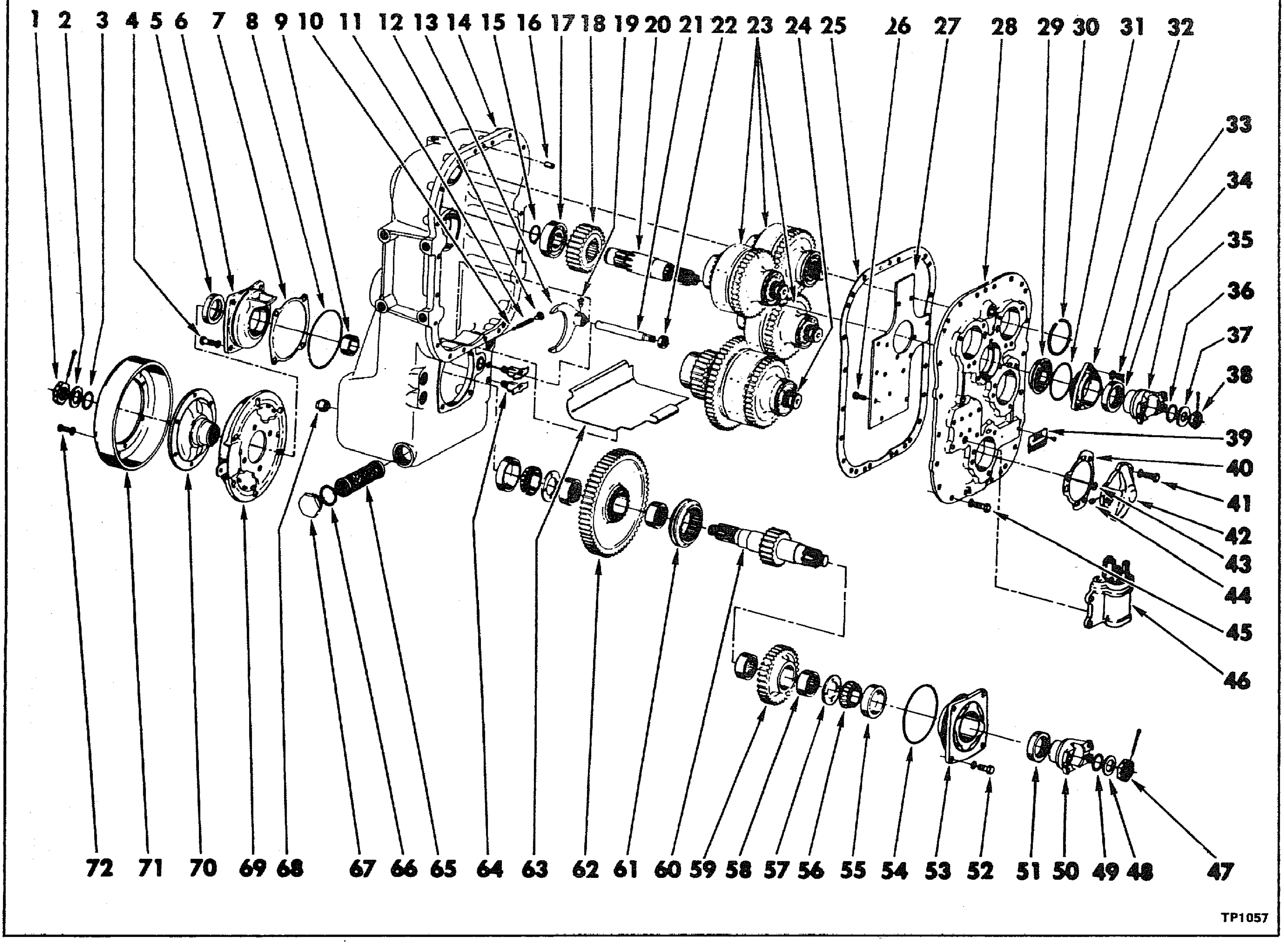


Fig. 81

Install the torque converter on the engine, mounting i squarely on the flywheel housing so that the ring gea and pilot bearing engage mating parts in the engin Secure with bolts torqued to 20 to 25 lb. ft. torque.


1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
33 34 35 36 37 38 39 40 41 42 43 44 45 46
72 71 70 69 68 67 66 65 64 63 62 61 60 59 58 57 56 55 54 53 52 51 50 49 48 47
TP1057

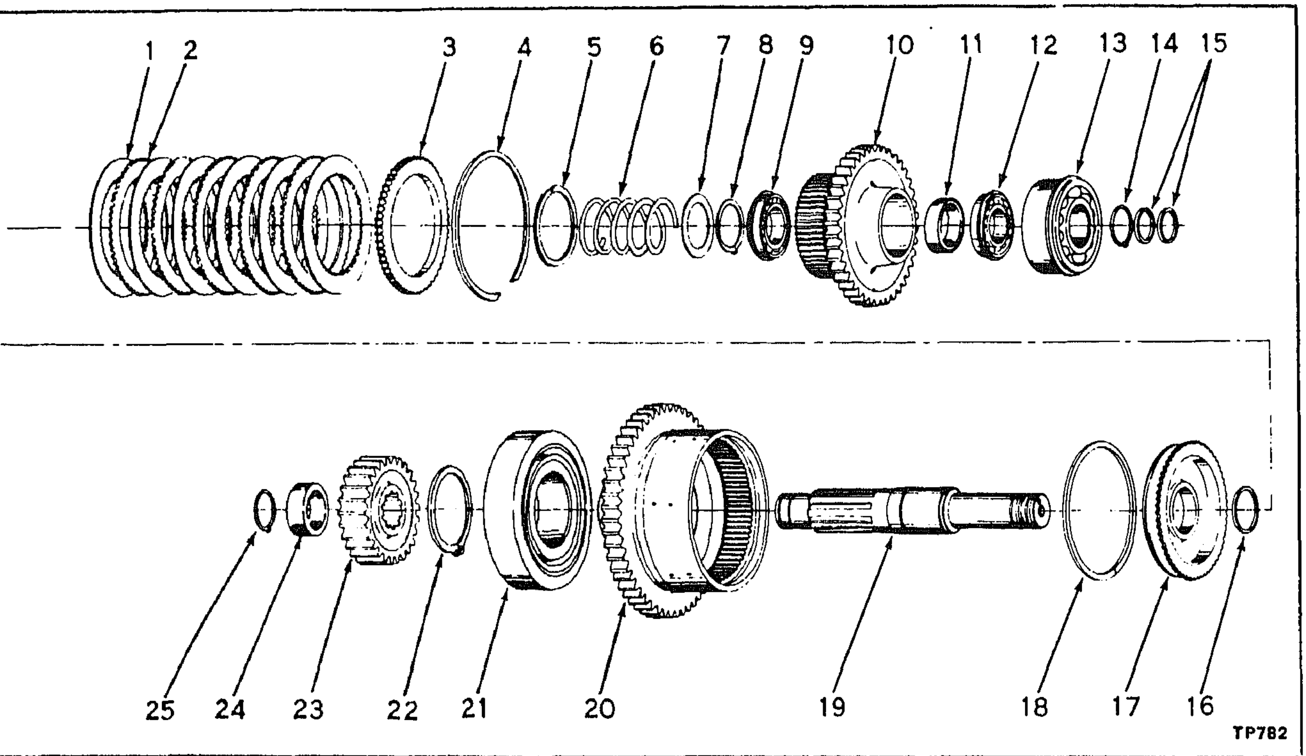
Item	Part No.	Description	No. Req'd.
A	2067761	Transmission Assy. (Incl. Items 1 thru 72A)	1
1	6900826	Nut, Flange	1
1A	6900827	Pin, Cotter	1
2	6900812	Washer	1
3	6900811	"O" Ring	1
4	2031519	Screw, Bearing Cap	4
4A	6900809	Washer, Lock	4
5	6900808	Seal, Oil	1
6	6900807	Cap, Bearing	1
7	2039422	Shim, .004 in. Thick	AR
7	2039423	Shim, .007 in. Thick	AR
7	2039424	Shim, .010 in. Thick	AR
8	2039491	"O" Ring	1
9	6900830	Spacer, Brake Flange	2
10	2039490	Ball, Detent	1
11	2039381	Spring, Detent	1
12	2033383	Plug, Detent	1
13	2039383	Fork, Range Shift	1
14	6900832	Case, Transmission	1
14A	6950119	Plug, Case Bore (N.I.)	1
15	2039262	Ring, Retaining	1
16	2039343	Pin	2
17	2039336	Bearing, Input Shaft	1
18	2039337	Gear, Input Shaft	1
19	2039382	Screw, Lock, Range Shift	1
20	2039355	Shaft, Input	1
21	6901253	Rail, Range Shift	1
22	2039375	Seal, Oil	1
23	———	Forward, Reverse & Low Clutch Group (See Sep. Illus.)	
24	———	High Clutch Group (See Sep. Illus.)	
25	2039294	Gasket	1
26	2031474	Screw, Plate to Cover	15
26A	6951321	Washer, Lock	15
27	2039346	Plate	1
28	2039334	Cover, Transmission	1
29	2039363	Bearing Assy., Input Shaft (Incl. Item 30)	1
30	———	Ring, Locating (N.S.S.)	1
31	2039453	"O" Ring	1
32	6900800	Cap & Seal Assy., Input Shaft Bearing (Incl. Item 34)	1
33	2031497	Screw, Bearing Cap	3
33A	2031391	Washer, Lock	3

Item	Part No.	Description	No.
34	2039297	Seal, Oil	
35	2022477	Flange, Input Shaft	
36	2039230	"O" Ring	
37	2039300	Washer, Flange	
38	2039301	Nut	
38A	2031772	Pin, Cotter	
39	6900834	Plate, Identification	
39A	2039273	Screw, Identification Plate	
40	2039362	Gasket	
41	2031497	Screw, Cap	1
41A	2031391	Washer, Lock	1
42	2039357	Cap, Distributor Bearing	
43	2039492	"O" Ring	
44	2039446	Plug, Pipe	
45	2031497	Screw, Cover to Case	2
45A	2031392	Washer, Lock	2
46	———	Transmission Control Valve Assy. (See Sep. Illus.)	
47	6900826	Nut, Flange	
47A	6900827	Pin, Cotter	
48	6900812	Washer	
49	6900811	"O" Ring	
50	2059449	Flange, Output Shaft	
51	6900805	Seal, Oil	
52	2031519	Screw	
52A	6900809	Washer, Lock	
53	6900807	Cap, Bearing	
54	2039491	"O" Ring	
55	6900823	Cup, Bearing	
56	6900822	Cone, Bearing	
57	6900806	Washer, Thrust	
58	6900803	Bearing, Output Shaft	
59	6900804	Gear, High	
60	6901272	Shaft, Output	
61	2039384	Hub, Output Shaft Shift	
62	6900802	Gear, Low	
63	6900838	Plate, Baffle	
64	2033212	Cock, Drain	
65	2039374	Screen Assy., Suction	
66	6950187	Gasket	
67	6950188	Plug, Suction Screen	
68	6901311	Plug, Magnetic Drain	
69	———	Parking Brake Assy. (See Sep. Illus.)	
70	6900831	Flange, Brake	
71	2039420	Drum, Brake	
72	2030789	Screw, Flange	
72A	2031391	Washer, Lock	

(N.I.) Not Illustrated

(N.S.S.) Not Serviced Separately

AR As Re



HIGH CLUTCH GROUP

m	Part No	Description	No. Req'd.
\	6955247	Clutch Pack Assy. (Incl. Items 1 thru 25)	1
1	6900790	Disc, Inner	6
2	2039353	Disc, Outer	5
3	2039351	Plate, Disc Backing	1
4	2039350	Ring, Retaining	1
5	2039328	Ring, Retaining	1
6	2039349	Spring, Piston Return	1
7	2039347	Washer, Return Spring	1
8	2039317	Ring, Retaining	1
9	2039341	Bearing	1
0	6900792	Hub, Gear & Clutch	1
1	6900791	Spacer, Bearing	1
2	2039341	Bearing	1
13	6900793	Bearing, Shaft	1
14	2039262	Ring, Retaining	1
15	2039354	Ring, Shaft Piston	2
16	2039332	Ring, Shaft Piston	1
17	2039338	Piston, Clutch	1
18	2039339	Ring, Outer Piston	1
19	2039333	Shaft & Plug Assy.	1
20	6900833	Drum & Gear Assy., Clutch	1
21	6900796	Bearing, Gear	1
22	6900795	Ring, Retaining	1
23	2039337	Gear	1
24	6900794	Spacer, Gear	1
25	2039262	Ring, Retaining	1

TRANSMISSION DISASSEMBLY

To remove the transmission from the vehicle, drain the transmission and torque converter hydraulic system, disconnect the three drive shafts, and disconnect all linkage. Disconnect the hydraulic system hoses from the transmission. Adequately support the transmission with a floor jack and remove the bolts that secure the transmission to the vehicle; remove the transmission.

CAUTION: Cleanliness is of extreme importance and an absolute must in the repair and overhaul of this transmission. Before attempting any repairs, the exterior of the unit must be thoroughly cleaned to prevent the possibility of dirt and foreign matter entering the mechanism.

Remove input companion flange, all exterior bearing caps, and control valve.

Remove transmission cover bolts and lockwashers (Fig. 82).

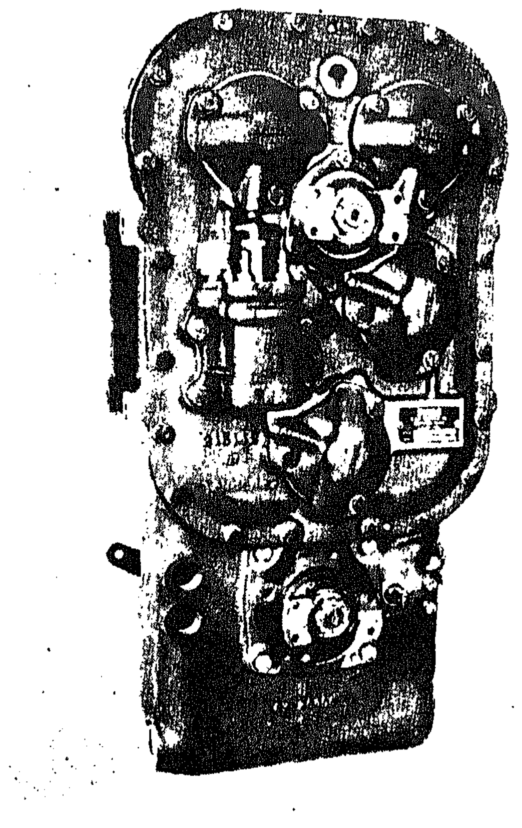


Fig. 82

Each bearing has a locating ring on it; remove rings, five in all (Fig. 83).

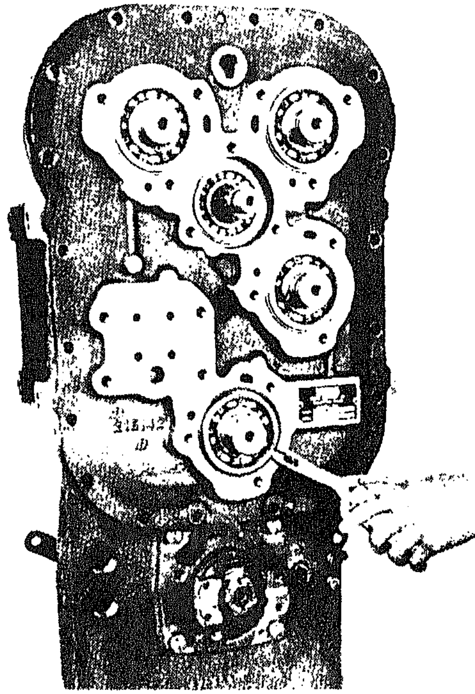


Fig. 83

Using a suitable tool, pry cover from transmissic

NOTE: As cover is being pried from case, ta shaft with a soft hammer to prevent i coming out with cover (Fig. 84).

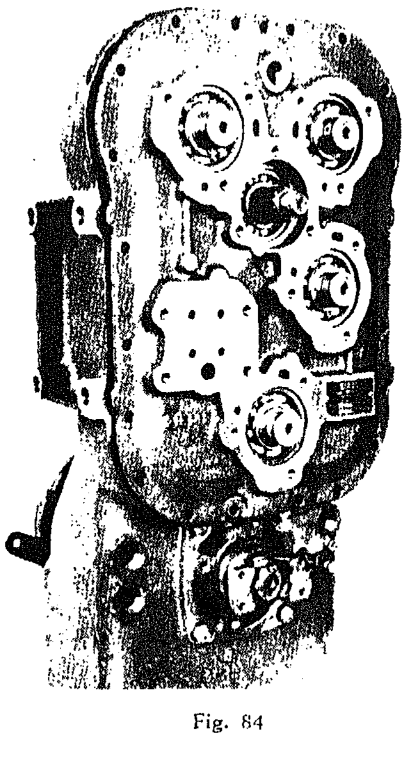


Fig. 84

Under the transmission cover is the oil circuit plate. When repairs are made, remove plate and check for dirt and foreign matter (Fig. 85).

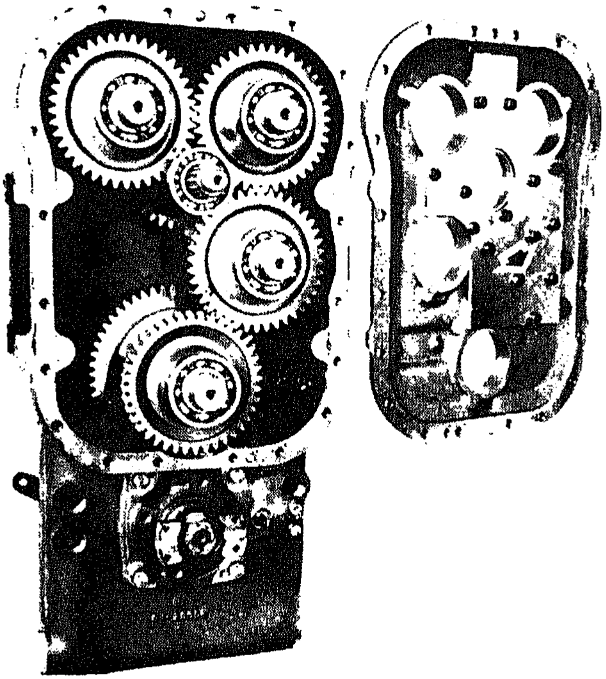


Fig. 85

Remove input shaft bearing (Fig. 86).

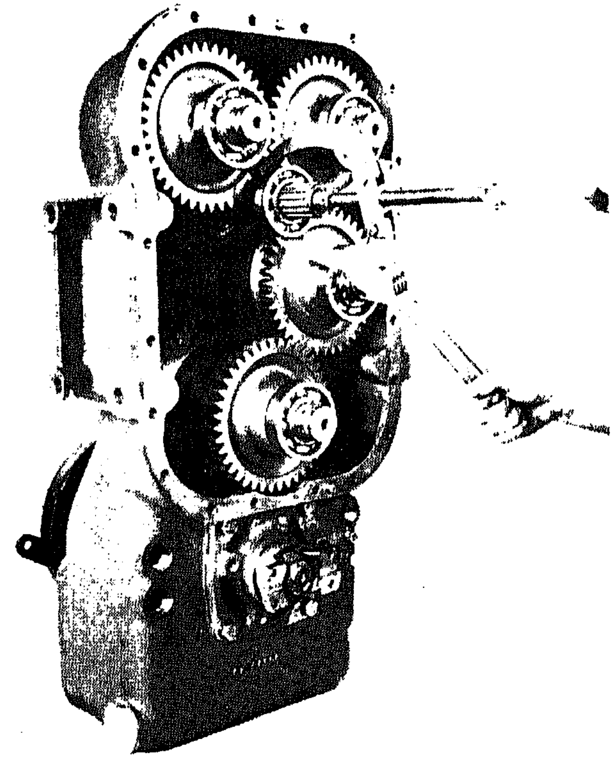


Fig. 86

The clutch packs must be removed in sequence A, B, C and D as shown in Fig. 87. Pull clutch B out of case about ⅝ inch to allow clutch A to pass clutch B. Pull clutch A from case.

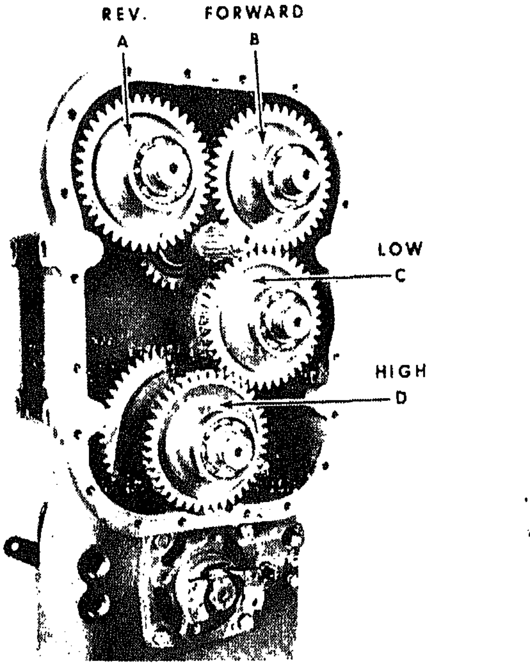


Fig. 87

With cluch A removed (Fig. 88), tap clutch B back in case. Pull clutch C out of case about ⅝ inch to allow clutch B to pass clutch C. Tap clutch C back in case and pull clutch D out of case about ⅝ inch to allow clutch C to pass clutch D. After clutch C has been removed, remove clutch D. Pull input shaft from case.

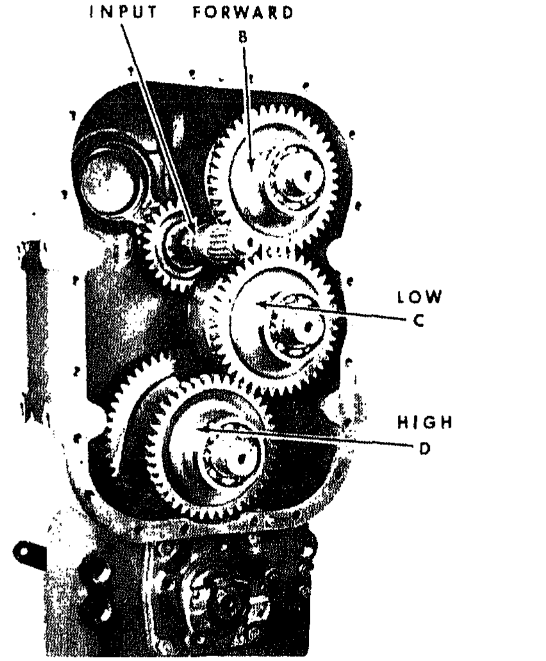


Fig. 88

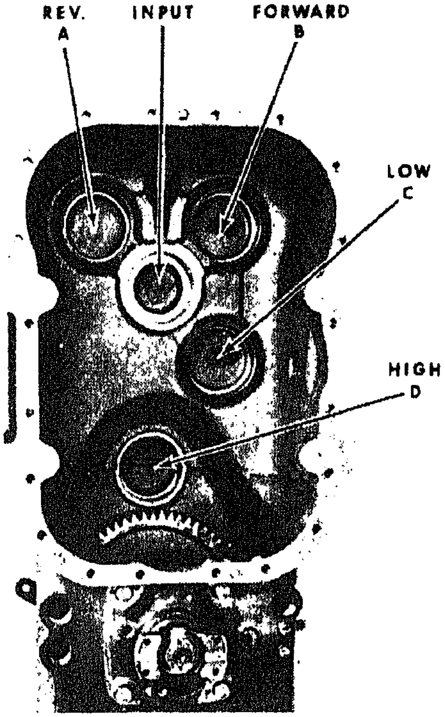


Fig. 89

nove brake drum flange nut and brake drum. Remove ke band retaining springs and brake bands (Fig. 90).

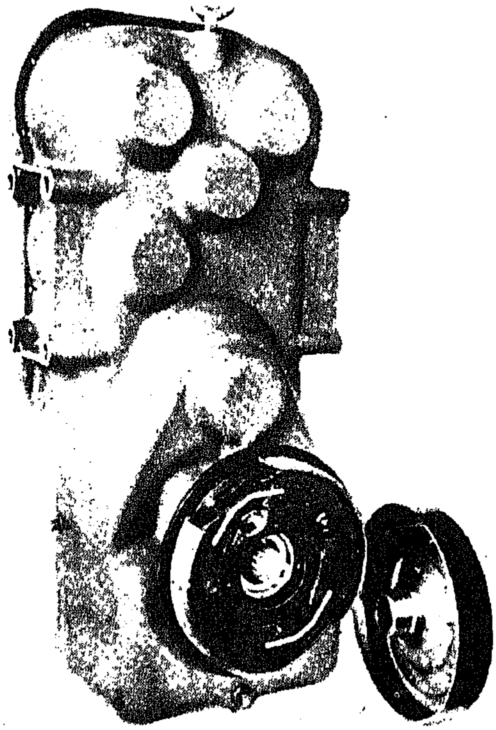


Fig. 90

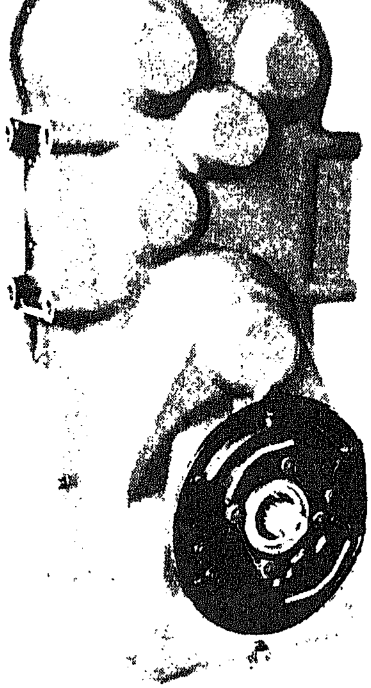


Fig. 91

Remove rear bearing lap (Fig. 92). Remove range shift rail detent plug (Fig. 92). Remove detent spring and ball. Remove range shift fork lockscrew. Remove range shift fork rail and shift fork.

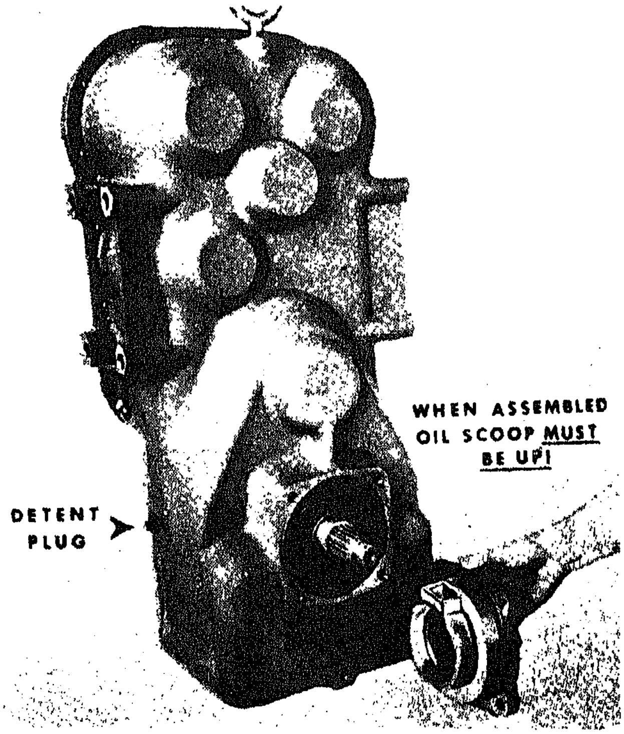


Fig. 92

Block low gear as shown in Fig. 93. Using a soft hammer at the brake end of the output shaft, drive the shaft and high gear front bearing from transmission case.

CAUTION: High gear will pass through bore in case, but care must be used to prevent damage of gear teeth or transmission case bore.

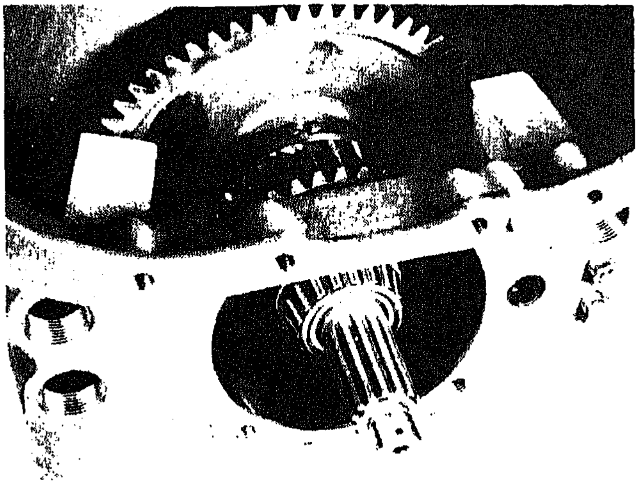


Fig. 93

Remove output shaft, high gear, and bearing as an assembly from the case (Fig. 94).

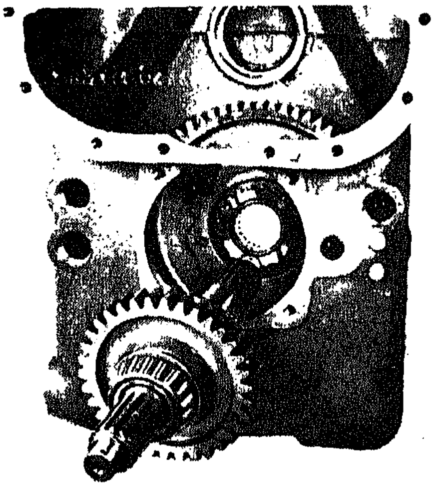


Fig. 94

Pull high gear and bearing from output shaft (Fig. 95). If bearings must be replaced, press bearings from high and low gears.

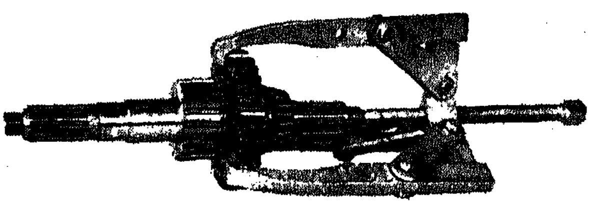


Fig. 95

Remove oil sump screen and oil baffle plate to facilitat cleaning (Fig. 96).

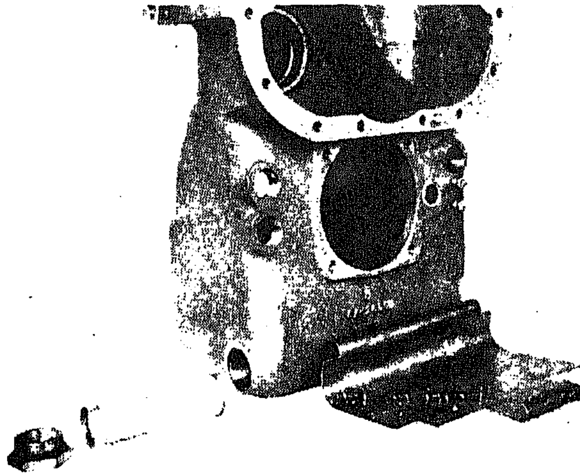


Fig. 96

TRANSMISSION CLUTCH DISASSEMBLY

To disassemble forward, reverse and low clutch assem blies, remove bearing retainer ring. Using suitabl puller, remove clutch disc hub gear and front gea bearing (Fig. 97).

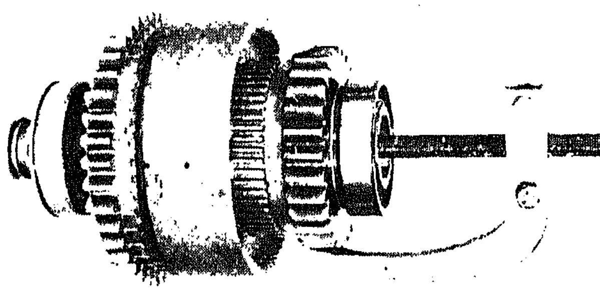


Fig. 97

Using a suitable puller, remove rear bearing (Fig. 98 Remove end plate retainer ring and end plate. Remo inner and outer clutch discs.

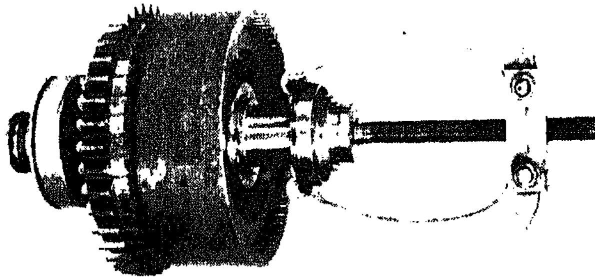


Fig. 98

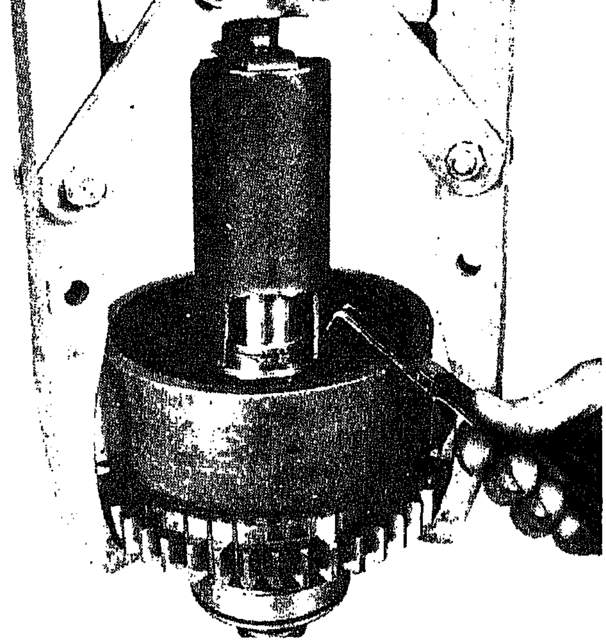


Fig. 99

piece of common pipe with a 2½ inch inside diameter, 2¾ inch outside diameter, and 5 inches long.

Remove clutch piston return spring and clutch piston (**Fig. 100**).

NOTE: High clutch disassembles the same as the forward, reverse and low clutches, except clutch shaft oil sealing rings are on the same end as the clutch disc hub and must be removed first instead of later, as in the other three clutches.

TRANSMISSION CONTROL VALVE DISASSEMBLY

Thoroughly clean the exterior of the valve to prevent entry of dirt into the valve. To disassemble the control valve, refer to Transmission Control Valve illustration

Remove cap (3) with "O" Ring (4).

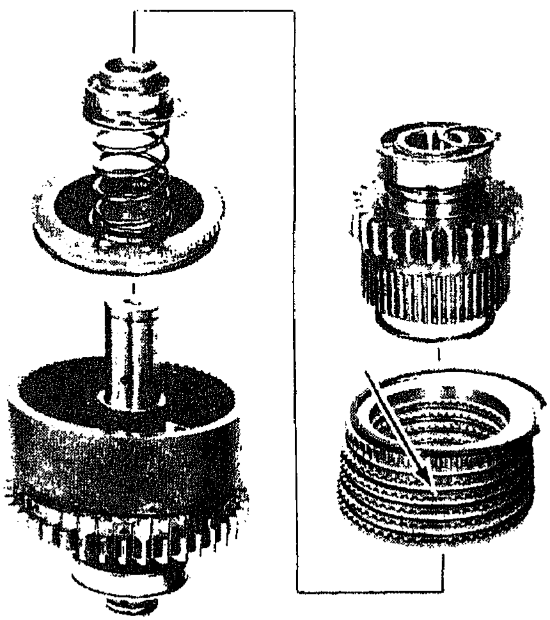
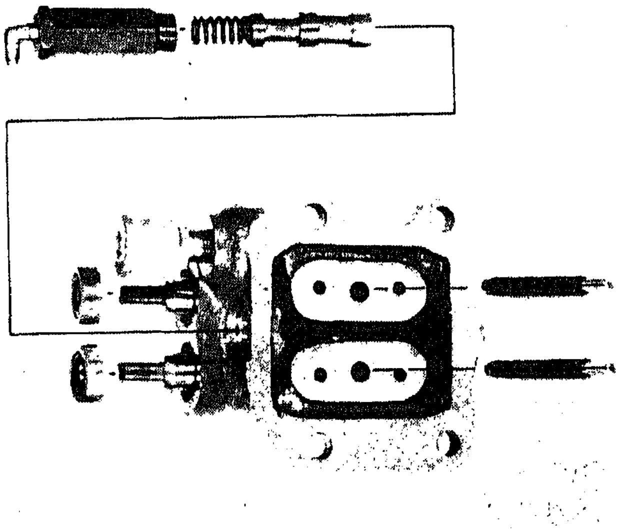
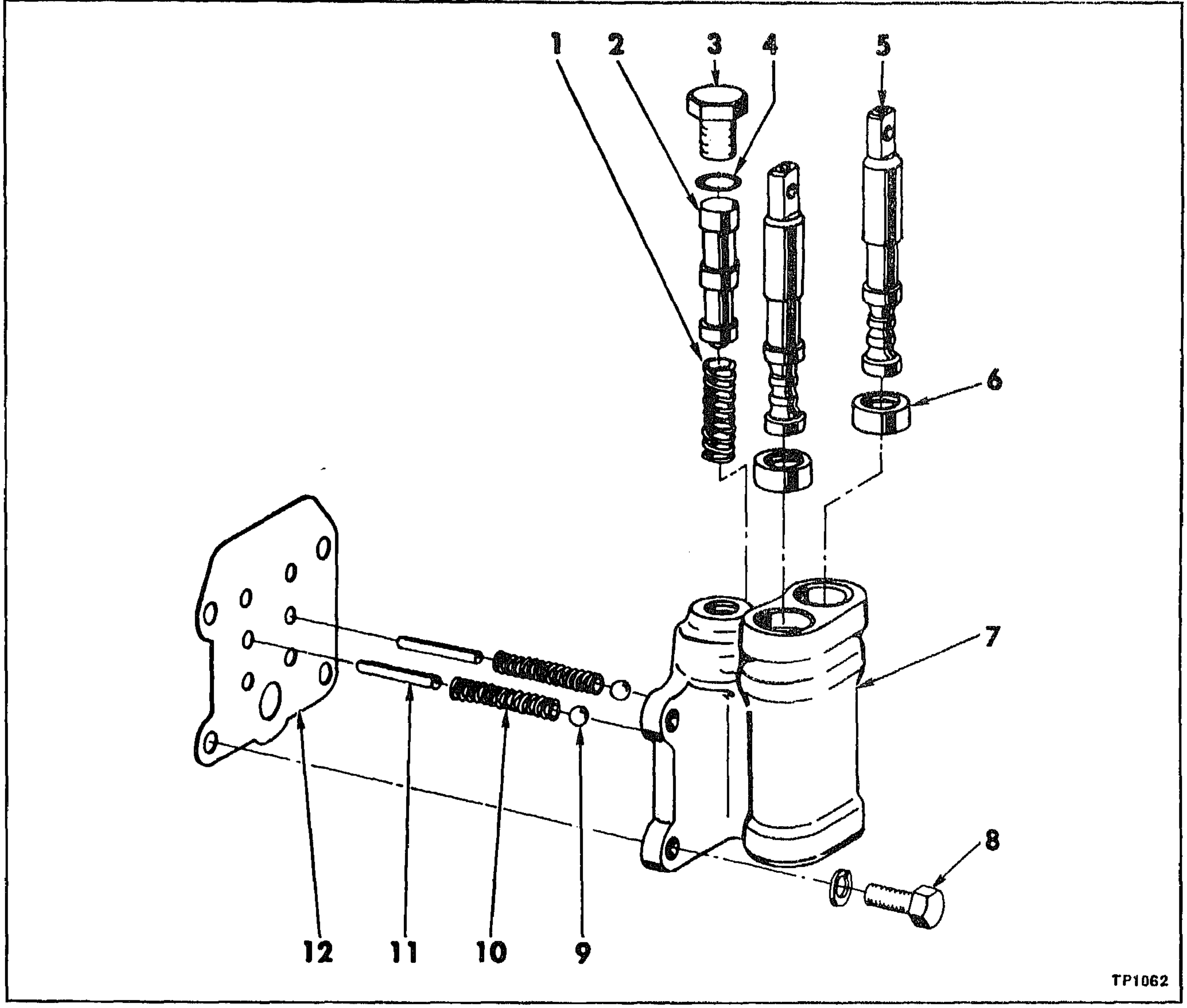


Fig. 100



Transmission Control Valve



TRANSMISSION CONTROL VALVE ASSEMBLY

Item	Part No.	Description	No. Req'd.
A	6901254	Valve Assy., Tansmission Control (Incl. Items 1 thru 12)	1
1	2039372	Spring, Return	1
2	6950110	Valve, Slave Unit Control	1
3	6901214	Cap (Incl. Item 4)	1
4	6750674	"O" Ring	1
5	6901255	Valve, Manual Control	2

Item	Part No.	Description	No. Req'd.
6	2039375	Seal, Oil	2
7	6950109	Housing, Control Valve	1
8	2031497	Screw, Housing to Cover	4
8A	2031392	Washer, Lock	4
9	2039490	Ball, Detent	2
10	2039378	Spring, Detent	2
11	2039379	Pin, Detent Stop	2
12	2039377	Gasket	1

T H I N K

Never leave operators seat with the engine running.

WHEN ORDERING PARTS ALWAYS FURNISH SERIAL NUMBER OF MACHINE

TRANSMISSION CLEANING AND INSPECTION

Cleanliness of the respective parts is absolutely necessary in reassembling. Dirt in its many forms can and will cause trouble. Therefore, before reassembling the transmission or any of its parts, be sure all parts have been thoroughly cleaned with suitable cleaning fluid. After cleaning, all parts should be dried with moisture-free, compressed air.

A thorough visual examination of all parts should be made before reassembly. Any parts that show excessive wear or damage should be replaced. Small nicks or burrs may be removed with a hone or crocus cloth. It is recommended that all gaskets, oil seals, piston sealing rings, "O" rings and internal lockwashers be replaced. The use of grease is recommended when positioning new gaskets in their respective locations. Piston sealing rings and "O" rings should be coated with type "A" Automatic Transmission Fluid to facilitate assembly.

TRANSMISSION CLUTCH REASSEMBLY

Before reassembling the clutch, lubricate all parts with a light coating of type "A" Automatic Transmission Fluid. Refer to Forward, Reverse, and Low Clutch illustration for parts identification.

Install new piston outer sealing ring (8) on piston.

Install new piston inner sealing ring (9) on clutch shaft. Install piston (7) in clutch drum (10).

Install piston return spring (6) on clutch shaft.

Position return spring washer (5) and retaining ring (4).

Compress spring and washers as shown in Fig. 99 and install washer retaining ring.

Install one bronze disc (1). Each steel disc has a 0.015 to 0.020 dish in them. Each steel disc has two oil grooves 180 degrees apart on the outer diameter.

Install one steel disc (2) with dish away from repairman.

Install one bronze disc (1).

Install second steel disc (2) with dish away from repai man and oil grooves lined up with oil grooves in fi steel disc.

Follow this sequence until five steel discs and six bron discs have been installed, being sure the dish on t steel discs are away from the repairman and the grooves are all lined up.

Install end plate (14) and retaining ring (15).

NOTE: There should be about 1/8 inch clearance b tween the last bronze disc and the end plat

Install one disc hub bearing (19) (bearing ring dowr on the clutch shaft.

Install bearing spacer (18) (oil groove down) on t clutch shaft.

Install clutch disc hub (17) into clutch drum, alignir the internal teeth on the bronze disc with the spline the disc hub. The hub bearing on the clutch shaft w have to be worked into the clutch disc hub. It is a slip and must not be forced.

CAUTION: Be sure clutch disc hub is in full positic with teeth on all bronze disc.

On the reverse, forward and low clutch, the distan between the bottom face of the clutch disc hub ge teeth and the clutch end plate is about 7/16 inch. T high clutch has a distance of about 5/32 inch. A mea urement larger than these indicates the bottom bron disc is not engaged with the clutch disc hub.

Press second disc hub bearing (20) (bearing ring u in disc hub.

NOTE: Bearing ring will not bottom on disc hu bearing bottoms on bearing spacer in hub.

Install clutch shaft rear bearing (11) and bearing taining ring (12).

TRANSMISSION CONTROL VALVE REASSEMBLY

The internal parts of the transmission control valve are highly machined and polished. Handle the parts carefully to prevent scratching or nicking. Take care to prevent the entry of dirt or dust particles which will damage the surfaces. Refer to the Transmission Control Valve illustration for parts identification.

Install the return spring (1) and slave unit control valve (2) in the housing (7). Install the cap (3) with "O" Ring (4).

Install the two manual control valves (5) in the control valve housing (7); install the oil seals (6).

TRANSMISSION REASSEMBLY

Install oil baffle plate and oil sump screen (Fig. 96).

If bearings were pressed from high and low gears, proceed as follows:

Press one bearing in gear. Press second bearing on top of first bearing. Bearings will be together in the center of gear.

NOTE: Bearings must be from .015 to .025 inch from face of gear hub. Check both sides of gear hub to be sure bearings are below face of gear.

Install high gear (34 teeth) and bearing assembly on output shaft. Clutching teeth on gear go toward hub on output shaft. Install thrust washer next to high gear.

Press cone bearing on shaft to bottom on washer (Fig. 101).

NOTE: Press bearing against thrust washer tight enough so that washer will not turn on shaft.

Install low gear (61 teeth) and bearing assembly in housing with clutching teeth on gear toward center of case (Fig. 94).

Install range selector shift hub on shaft. Install high gear and shaft assembly through case bore and into low gear.

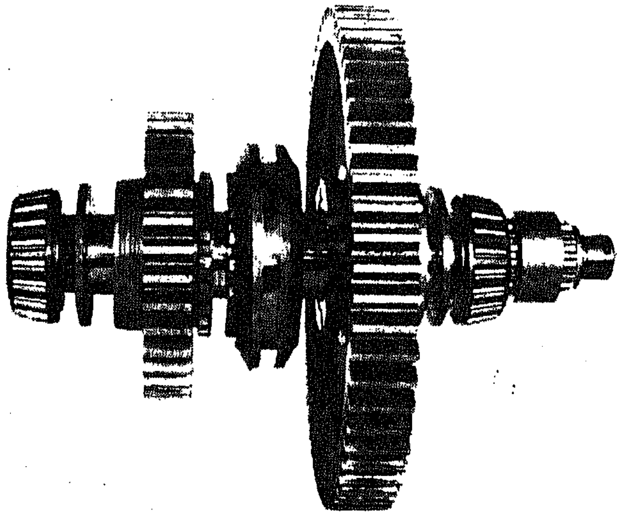


Fig. 101

Install new "O" ring on disconnect housing. Install disconnect on output. Install bolts and lockwashers; tighten securely.

CAUTION: Oil hole in disconnect housing must be up when installed.

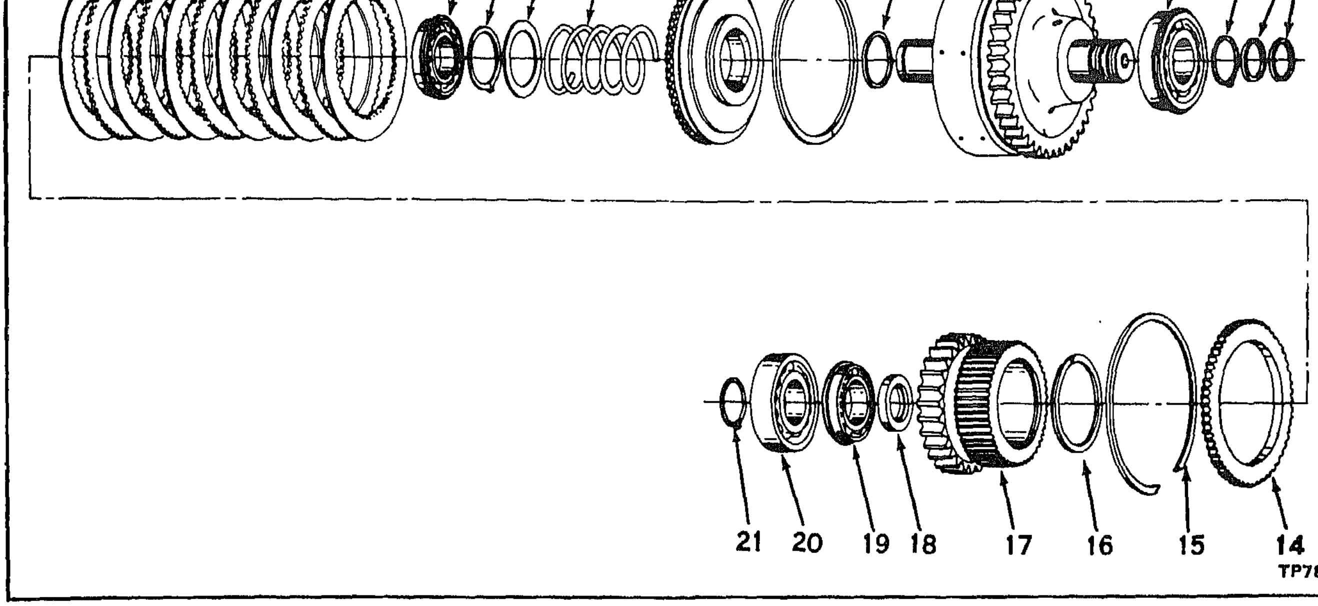
Install low gear thrust washer on rear end of output shaft.

Drive rear bearing on output shaft.

NOTE: Bearing must be tight enough against thrust washer so that washer will not turn on shaft. Install companion flange spacer.

Press oil seal in rear bearing cap, lip of seal in. Install new "O" ring on cap.

Install shims on bearing cap; install bearing cap assembly on transmission housing. (See Fig. 92). Oil hole must be up. Shims may be added or omitted to obtain 6 to 10 lb. in. torque on cone bearing.



FORWARD, REVERSE AND LOW CLUTCH GROUP

(Parts Shown Are For One Clutch Only)

Item	Part No.	Description	No. Req'd.
A	6955248	Clutch Pack Assy. (Items 1 thru 21)	1
1	6900790	Disc, Inner	6
2	2039353	Disc, Outer	5
3	2039341	Bearing	1
4	2039317	Ring, Retaining	1
5	2039347	Washer, Return Spring	1
6	2039349	Spring, Piston Return	1
7	2039338	Piston, Clutch	1
8	2039339	Ring, Outer Piston	1
9	2039332	Ring, Shaft Piston	1
10	6900835	Drum, Gear & Shaft Assy., Clutch	1
11	6900793	Bearing, Clutch Shaft	1
12	2039262	Ring, Retaining	1
13	2039354	Ring, Shaft Piston	2
14	2039351	Plate, Disc Bearing	1
15	2039350	Ring, Retaining	1
16	2039328	Ring, Retaining	1
17	2039348	Hub, Gear & Clutch	1
18	2039345	Spacer, Bearing	1
19	2039341	Bearing	1
20	2039336	Bearing, Clutch Shaft	1
21	2039262	Ring, Retaining	1

NOTE: Use caution not to damage bearing cap "O" ring.

When proper preload is obtained, install brake backing plate, brake band assembly, and brake drum (Fig. 90). Install range selector fork in shift hub.

Install range selector rail in fork and secure with lock-screw and lockwire. Install detent ball, spring and plug in detent hole. (See Fig 92).

Install input shaft gear and bearing assembly in center bore of transmission case (Fig. 88).

Install clutch D in bottom bore of case (Fig. 88). Pull clutch D out of case about ⅝ inch to allow clutch C to pass clutch D. Tap clutch D back in case and pull clutch C out of case about ⅝ inch to allow clutch B to pass clutch C. Tap clutch C back in case and pull clutch B out of case about ⅝ inch to allow clutch A to pass clutch B. Tap clutch B back in case. Tap all clutch shafts until they bottom in bore of case.

Install input shaft front bearing (Fig. 86).

Install new case housing cover gasket.

Be sure oil circuit plate is in place and tightened securely (Fig. 85).

Align clutch shaft bearings with bearing bores in case housing cover; tap cover on case housing (Fig. 84).

Install bolts and lockwashers and tighten evenly, all the way around cover.

CAUTION: Make sure input shaft bearing is not binding in cover.

In the end of each clutch shaft is a 7/16-inch—20 threaded hole. By using a 7/16-inch x 20 bolt in the threaded hole in the clutch shaft, pry each shaft out enough to permit assembly of the bearing locating rings (five in all) (Fig. 83). Make sure rings are properly seated. Tap each shaft until bearing ring shoulders against case cover.

NOTE: Check clutch shaft oil sealing rings. Make sure none are broken or damaged and all are locked properly.

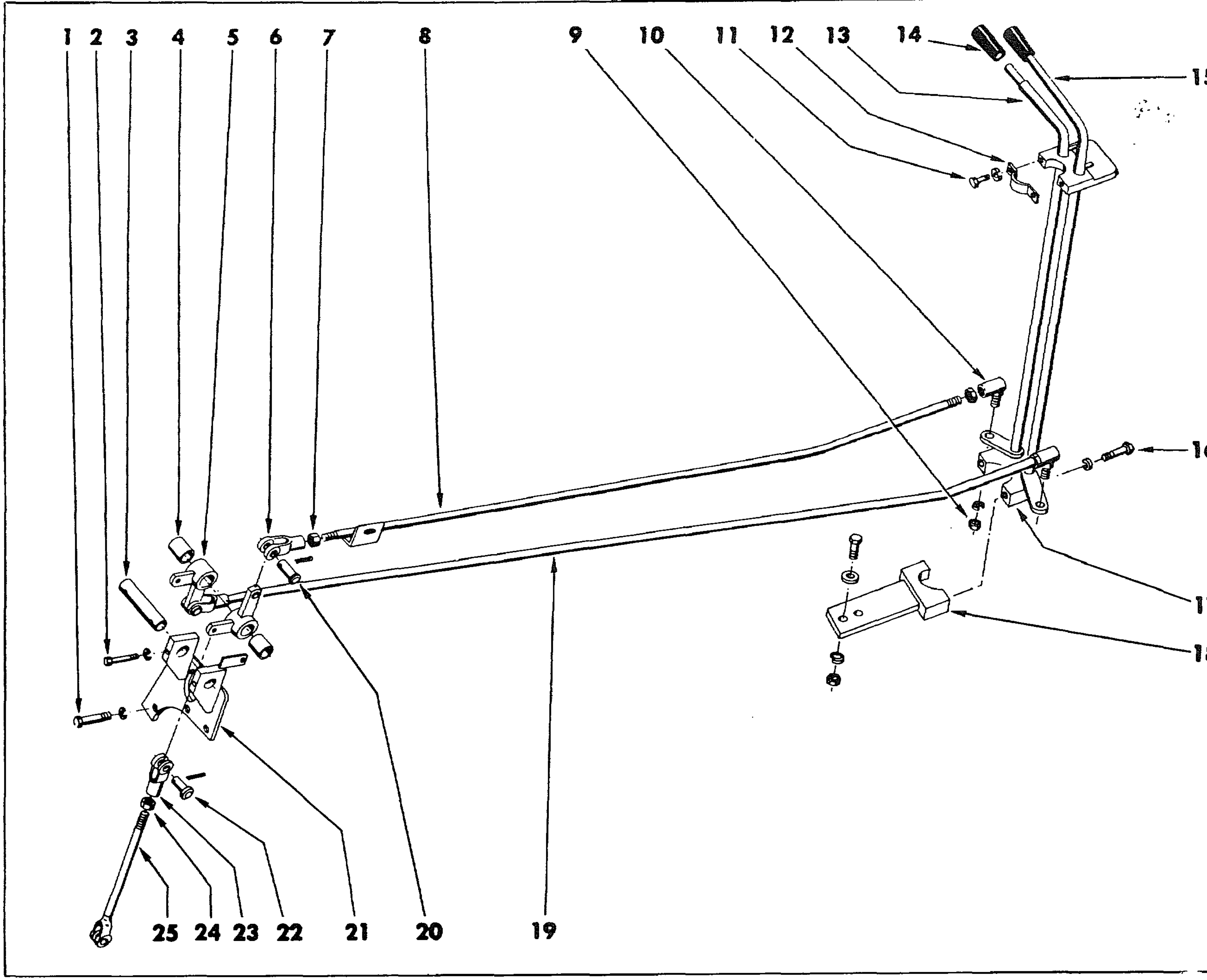
Install new gaskets and "O" rings on clutch distributor bearing caps.

Press new oil seal in input shaft bearing cap, lip of oil seal in. Oil seal must be pressed 5/16 inch from front face of bearing cap.

Install all bearing caps with bolt and lockwashers and tighten securely (Fig. 82).

Install "O" rings, flange nut washers, and flange nuts; secure with cotter pins.

With detent balls, springs, and pins in position, install control valve assembly.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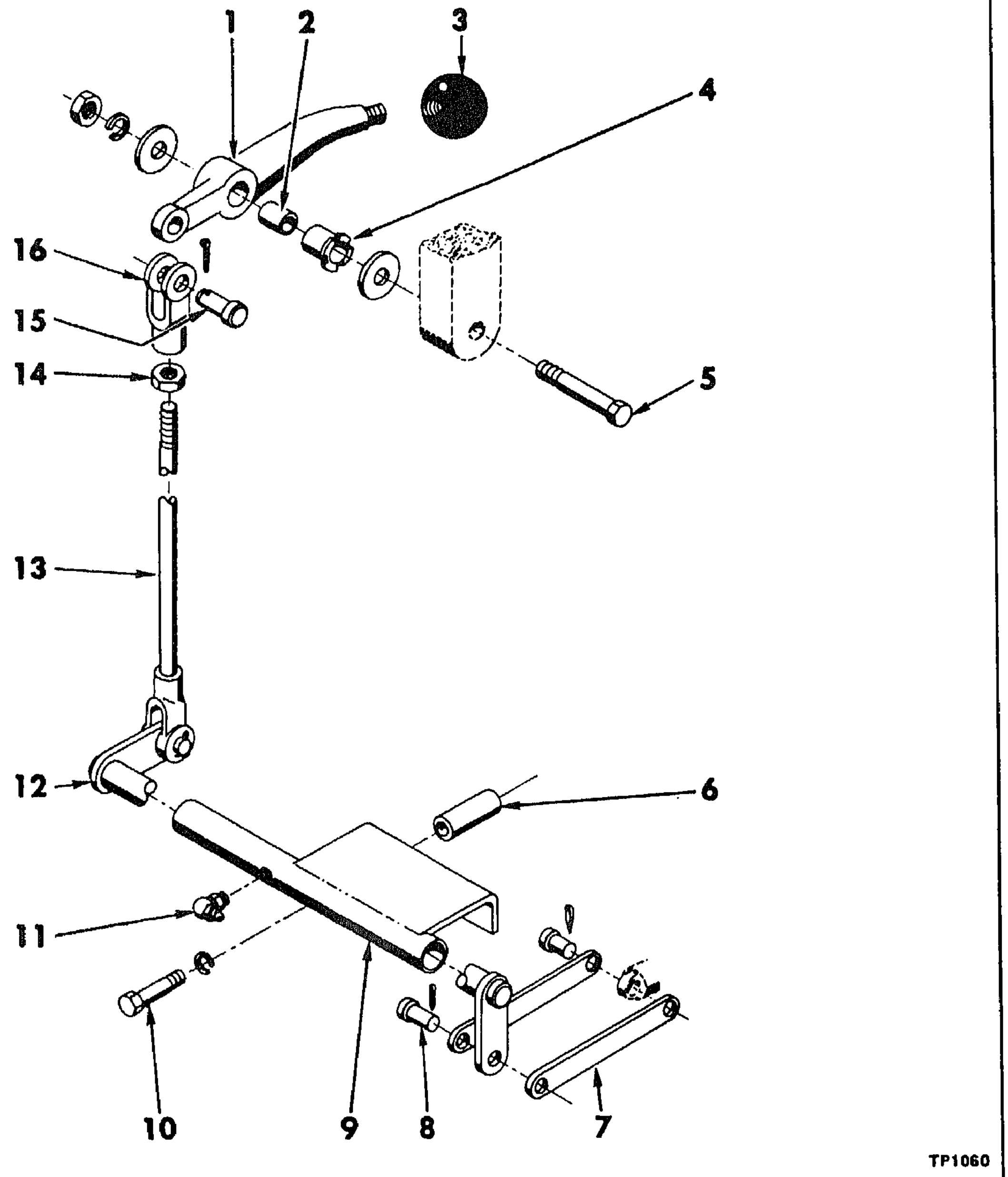
TRANSMISSION CONTROLS

Item	Part No.	Description	No. Req'd.
1	2031504	Bolt, Mount Plate to Transmission	3
1A	2031392	Washer, Lock	3
2	2031460	Bolt, Bellcrank to Pinlock	1
2A	2031390	Washer, Lock	1
3	2056313	Pin, Bellcrank to Mount	1
4	2047781	Bushing	2
5	2058897	Bellcrank Assy.	2
6	2031678	Clevis	2
7	2033517	Nut, Jam	4
8	2059920	Shift Rod Assy.	1
9	2031373	Nut	2
9A	2031393	Washer, Lock	2
10	2046332	Joint, Ball	2
11	2030791	Bolt	2
11A	2031391	Washer, Lock	2
12	2031704	Clamp	1
13	———	Lever 1-2 (N.S.S.) (Order Item 15)	1
14	2033542	Handle	2
15	2058893	Lever Assy. (Incl. Item 13)	1
16	2030803	Bolt	2
16A	2031391	Washer, Lock	2
17	2051971	Block	1
17A	2031700	Washer (N.I.)	2
18	2062440	Mount Bar Assy.	1
18A	2031523	Bolt	2
18B	2032962	Washer, Flat	2
18C	2031393	Washer, Lock	2
18D	2031619	Nut	2
19	2059919	Rod, Shift	1
20	2012942	Pin, Clevis	2
20A	2031768	Pin, Cotter	2
21	2056256	Mount Plate, Transmission Bellcrank	1
22	2031662	Pin, Clevis	4
22A	2031763	Pin, Cotter	4
23	2031676	Clevis	2
24	2033515	Nut, Jam	2
25	2056311	Rod Assy., Transmission to Bellcrank	2

(N.S.S.) Not Seviced Separately

(N.I.) Not Illustrated

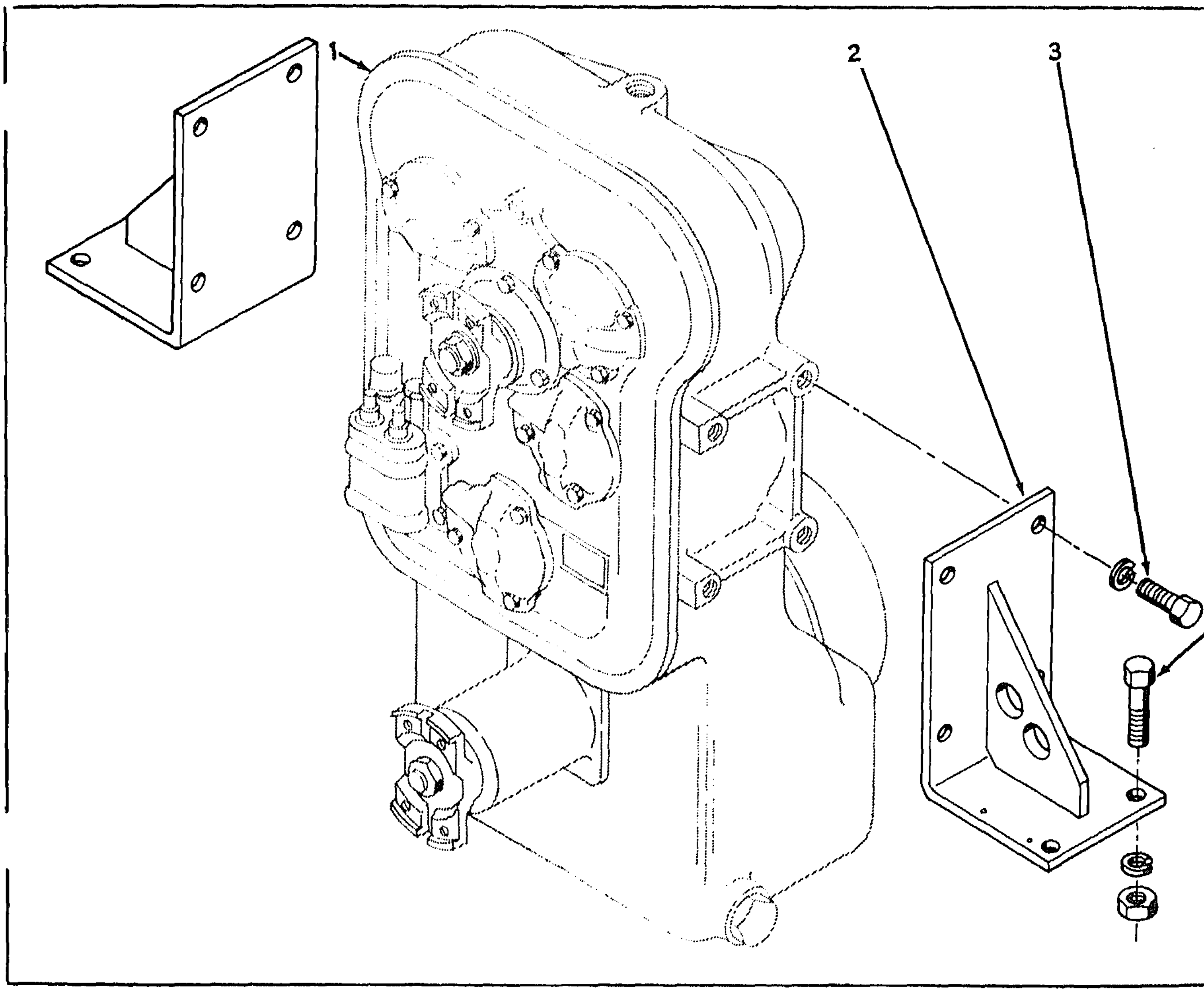


HI-LO TRANSMISSION CONTROL

m	Part No.	Description	No. Req'd.
	2040892	Lever, Hi-Lo Range	1
	2031693	Sleeve	1
	2033511	Knob	1
	2030659	Bushing	1
	2030882	Bolt	1
A	2032964	Washer, Flat	2
B	2031395	Washer, Lock	1
C	2031375	Nut	1
	2061180	Spacer	2
	2062319	Link	2
	2012391	Pin, Clevis	2
A	2031764	Pin, Cotter	2

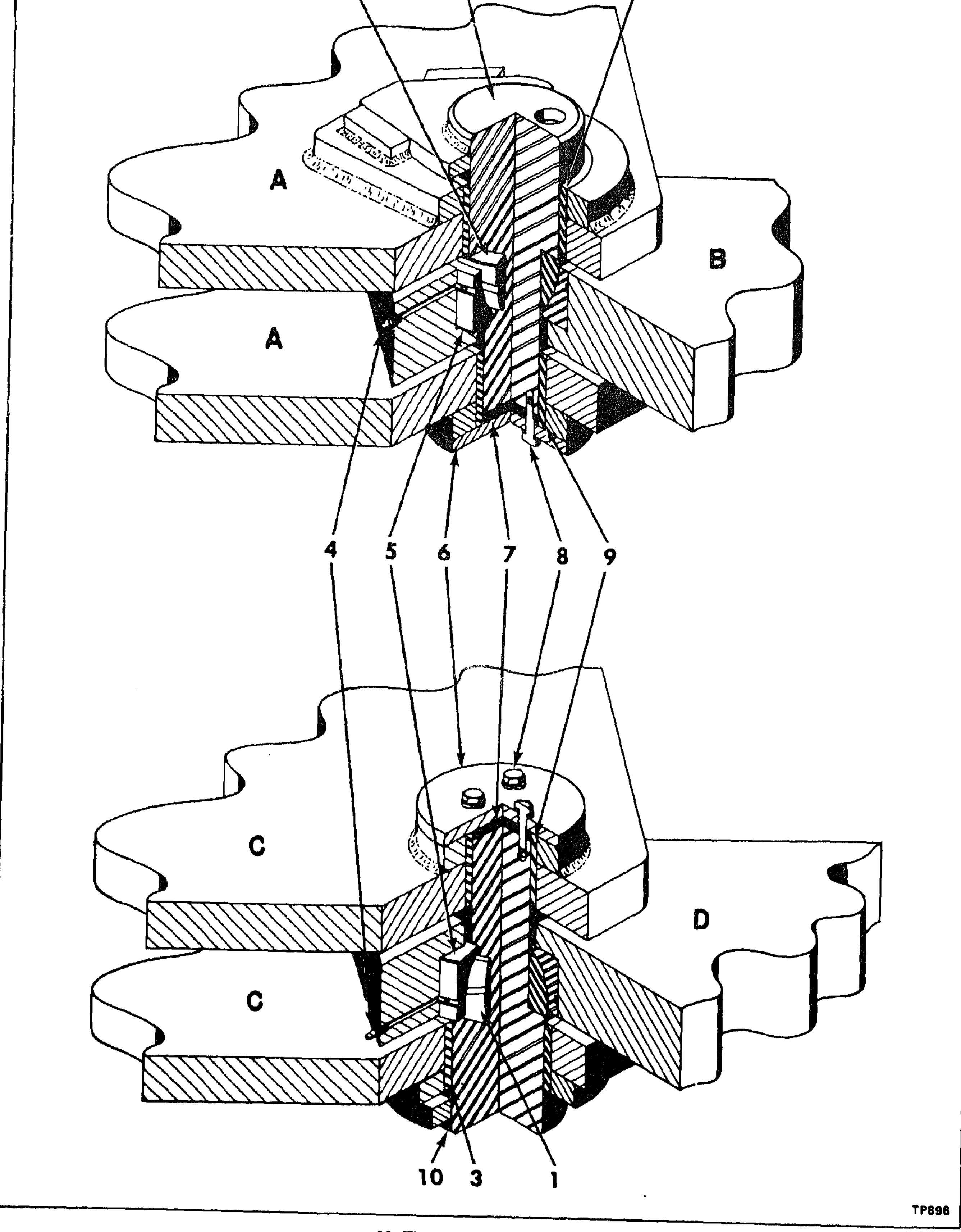
Item	Part No.	Description	No. Req'd.
9	2067850	Bellcrank Assy. (Incl. Item 12)	1
10	2031509	Bolt	2
10A	2031392	Washer, Lock	2
11	2033247	Fitting, Grease	1
12	———	Rod Assy. (N.S.S.) (Order Item 9)	
13	2062317	Rod Assy.	1
14	2033517	Nut, Jam	1
15	2010556	Pin, Clevis	2
15A	2031769	Pin, Cotter	2
16	2031678	Clevis	1

.S.S.) Not Serviced Separately



TRANSMISSION MOUNTING

Item	Part No.	Description	No. Req'd.
1	———	Transmission Assy. (See Transmission Section) ..	1
2	2060026	Bracket Assy.	2
3	2031577	Bolt, Bracket to Transmission	8
3A	2031396	Washer, Lock	8
4	2031579	Bolt, Bracket to Frame	4
4A	2032965	Washer, Flat	4
4B	2067438	Nut	4



MAIN PIVOT GROUP

PIVOT GROUP

Item	Part No.	Description	No. Req'd.
A	(Reference)	Pivot Crossmember, Upper Rear	
B	(Reference)	Pivot Crossmember, Upper Front	
C	(Reference)	Pivot Crossmember, Lower Rear	
D	(Reference)	Pivot Crossmember, Lower Front	
1	2060383	Bearing, Thrust, Inner Race	2
2	2067224	Pin Assy., Upper Pivot (Incl. 1 of Item 1)	1
3	2060119	Sleeve, Outer Pivot Crossmember	2
4	2033250	Fitting, Grease	2
5	2060382	Bearing, Thrust, Outer Race	2
6	2060341	Plate, Pin Retainer	2
7	2060342	Shim, Bearing Adjustment (.025)	AR
7A	2060343	Shim, Bearing Adjustment (.005)	AR
8	2031560	Bolt, Plate to Pin	6
8A	2031395	Washer, Lock	6
9	2060338	Sleeve, Inner Pivot Crossmember (Incl. 1 of Item 1)	1
10	2067225	Pin Assy., Lower Pivot	1

AR As Required

MAIN PIVOT

The machine consists of two frame sections. The two sections are held together at the rear of the front section and front of the rear section by two pivot pins. The frame sections pivot on two self-aligning bearings. Lubrication is provided through the lube fittings on the rear tongue of front section. Refer to the Lubrication Section of this manual (see Index) for correct lubricant. Two steering cylinders turn the frame sections. (See Steering System.)

Before attempting to remove the main pivot pins, the machine must be on level terrain with the complete cutting edge of the bucket flat on the ground. Be sure engine is shut off. (See Engine Shut Down Procedure.)

TOOLS REQUIRED

A suitable chain fall should be provided to lift the front section while it is being removed. A ten-ton chain fall will be sufficient. You will also need a small hydraulic jack. During disassembly, the rear frame section must be supported and kept as level as possible. Steel saw horses or sufficient hard wood blocking may be used. Horses or blocking, which ever used, should be wider than the rear frame section to keep the frame section level.

COMPONENT DISASSEMBLY

Block both rear wheels front and back to insure machine is stationary. Jack up front of rear frame section to remove weight from pivot pins. Due to the extreme weight of the vehicle, support the frame section with sufficient blocking. Remove jack to provide adequate working space with no danger of frame falling or shifting.

Install a one inch pipe nipple in the drain valve located beneath the main hydraulic reservoir. Connect a hose to the nipple and drain the hydraulic reservoir into a suitable container. Discard the used oil. Refill the reservoir with clean hydraulic oil when the work is finished on the pivot group. Refer to the Lubrication Section of this manual for capacity and type of oil used.

Remove the four main hydraulic system hoses from the junction blocks to the front section. Disconnect and remove the four hoses to the steering cylinders. Move hose away from working area.

Disconnect the two hoses leading from demand valv to steer valve at steer valve. Move aside.

CAUTION: When removing all hoses, care should b used not to spill an excessive amount o hydraulic oil in the working area. Oi spilled on the machine and ground wil cause a slippery condition. Wipe excess oi for personal safety.

Disconnect the brake line hose below the steering gea assembly. Move hose away.

Support the front frame section with a hoist. Disconnec the front steering cylinder pivot pins as directed in th Steering Hydraulic Section. It is not necessary to com pletely remove the steering cylinder to work on th lower pivot group. Compress rods of steering cylinder into cylinder tube. This will give more working area

Disconnect the steering linkage bellcrank from th drag link ball stud and the steering rod assembly. Re move them from the machine to provide additiona room if needed. Remove steering bellcrank from top o main pivot group. Refer to steering gear and linkag group for parts identification. (See Index.)

Disconnect the ball slip joint from the transmissio brake flange and pillow block assembly. Move ball sli joint to a suitable location for storage.

MAIN PIVOT DISASSEMBLY

With both frame sections properly supported, follo the instructions below to remove the main pivot pin and bearing assemblies. Refer to main pivot installatio for parts identification.

Remove three capscrews (8), lower cap (6) and shim (7) from bottom of upper pivot. Lay aside.

Remove three capscrews and lockwashers (8) from to of lower pivot. Lift off cap (6) and shims (7). La aside.

With a suitable tool, press lower pivot pin out from to to down. Press upper pin up and out from underneat upper pivot crossmember.

With both upper and lower pivot pins removed, slid front frame section from rear section.

ance regulations, we do not recommend gaso-line or any other volatile solvent such as naphtha, benzene, etc. Less flammable fluid such as kerosene or mineral spirits should be used. Do not use a caustic solution. After drying thoroughly with clean cloth, lay parts on a clean surface for inspection.

Clean all parts in solvent before inspecting.

Inspect the mating surfaces of inner and outer race for nicks, burrs, pitting and cracks. Check mating surfaces for wear. If evidence of wear is present on either race, replace both races before reassembly. A worn race will wear a new race quickly.

Examine the inner walls of both upper and lower sleeves, for wear, nicks, pitting and cracks. Replace sleeves if wear renders them unfit for future use.

If parts are questionable, replace them at this time.

RACE REPLACEMENT

Should inspection reveal the outer race defective, the outer race will have to be driven out of tongue (B) and (D). Drive the upper race up and out. Drive the lower race down and out.

Before a new outer race can be installed, it should be frozen in a freezer for about eight hours. It is possible to freeze the outer race in dry-ice for three hours if a freezer is not available.

NOTE: Freezing the race before installation shrinks the race, thus making installation easier.

Drive outer race into tongue of front section as shown in pivot installation diagram. With race correctly seated in tongue, inspect race for nicks incurred during installation. Hone if necessary.

Sleeves (3) and (9) should be replaced if found to be damaged. The new sleeves are pressed into sleeve bore flush at both top and bottom.

REASSEMBLY OF FRAME SECTIONS

Lubricate INNER bearing race (1) in both top and bottom of the front frame crossmember (B) and (D) with a light coat of multi-purpose grease.

Install OUTER bearing race (5) over pivot pins (2) and (10) with small diameter of bearing race facing up.

Lubricate the outside of race with a light coat of multi-purpose grease.

Slowly guide tongue (B) and (D) of front frame section between crossmember (AA) and (CC) of rear frame section. The front section should be kept as level as possible while mating the frame sections. Align both top and bottom pin holes.

will not be flush with bore in top of crossmember (CC).

Install upper pin (2) with inner race attached into top pivot bore with flange of pin facing up. Position pin flange between cams. It will be necessary to tap pin to seat it properly. Pin will not be flush with bottom of pin bore when correctly seated. Tighten cam lock bolts securely.

With a steel scale, measure the distance between top of tongue (B) and (D) with bottom of top crossmember (A) and (C). This measurement at both top and bottom should be identical. Should your measurement differ, lift or lower front section accordingly or strike top of upper pivot pin to compensate for the difference. Correct measurement in this area is very important.

With a depth micrometer, measure the depth of lower pivot pin bore. This measurement should be taken in at least four different places to obtain the greatest measurement. With the correct depth measurement determined, deduct .010 for correct pressure. This measurement is the correct amount of shims required for installation.

Align holes in shims (7) and insert into pivot bore. Wipe off the machine surface of plate (6) and install lockwashers and capscrews (8) into plate. Position plate with capscrews over pin bore passing capscrews through shims. Screw capscrews into pin, finger tight. Insert the edge of your finger just between tongue (D) and top crossmember (C). Slowly tighten capscrews and observe the pressure of crossmember (C), on your fingertip. When you feel the pressure applied to your fingertip, the capscrews are secure.

This procedure is the same for shimming the upper pivot pin with the exception of installing shims and retainer plate. With the correct amount of shims selected, place them on retainer plate (6) and pass the capscrews and lockwashers htrough plate. Lift plate (6) with shims on up into bottom pin bore. Tighten capscrews finger-tight.

Insert the tip of your finger between tongue of front section (B) and top of lower crossmember (A). Slowly tighten capscrews (8) until pressure is felt. When pressure is felt on tip of your finger, the capscrews are secure.

CHECKING MOVEMENT

Lift front frame section off blocking. Remove blocking. Front frame section should now swing freely with little effort.

REASSEMBLY OF COMPONENTS

Reassemble ball slip joint between transmission parking brake flange and rear yoke of pillow block. Use only special heat treated capscrews provided. Torque to 95 lbs. ft. torque.

Connect the four hoses from front frame section to junction blocks. New "O" rings should be used to insure proper sealing. It may be necessary to twist hoses to insure hoses are free from rubbing together. Refer to the main hydraulic illustration (see Index) for correct positions

Extend steering cylinder bodies and install base mounting pins as instructed in the Steering Hydraulic Section of this manual. Connect hoses to steering cylinder ports. Refer to the steering hydraulic system illustration (see Index) for correct hose position.

Connect the two hoses from demand valve to steer valve at the steer valve. Refer to steering hydraulic system illustration for correct hose location.

Connect the brake line hose to junction block below th steering gear assembly.

NOTE: Each time a brake hose or connection is re moved, the brake system must be bled to re lieve the air taken into the brake line. Se Brake System. (See Index.)

Install steering linkage bellcrank to top of upper pivo pin. Connect drag link ball stud and nut to left side o bellcrank. Connect steering rod to right side of bell crank. Be sure all connections are free in movemen and tight.

Fill main hydraulic reservoir with clean hydraulic oil See Capacity Section (see Index) for correct amoun

Remove blocking from under rear frame section anc wheels.

Lubricate upper and lower pivot bearings as instructec in the Lubricating Section of this manual.

The pillow block is located between the two sections of the machine, forward of the main lower pivot. Under normal conditions, very little service is required except for lubricating. See lubrication chart for type of lubricant and time intervals.

CAUTION: Before performing work between the front and rear sections of the machine, INSTALL SAFETY LINK ON BOTH SIDES OF MACHINE. (See Fig. 5.)

REMOVING PILLOW BLOCK FROM MACHINE

Remove capscrews and nuts from front propeller shaft and ball slip joint. Loosen and remove pillow block mounting capscrews, nuts and lockwashers (14, 15, 16). Remove pillow block assembly from machine and move it to a suitable location for disassembly.

PILLOW BLOCK OVERHAUL

Do not disassemble the pillow block further than necessary to correct a malfunction. During disassembly special attention should be given to identification of parts for proper reassembly.

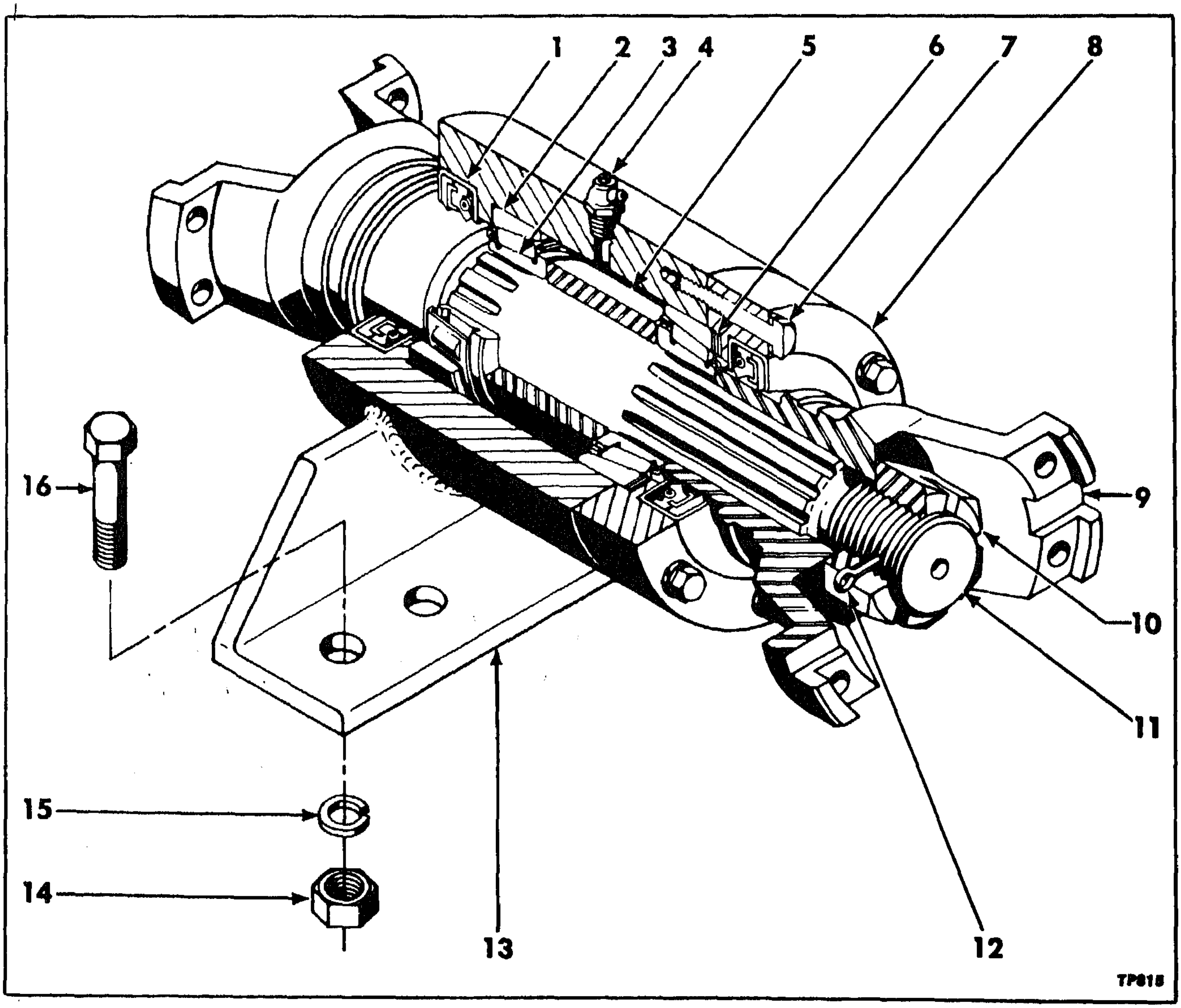
Cleanliness is of the utmost importance. Place all disassembled parts on a clean, lint-free surface.

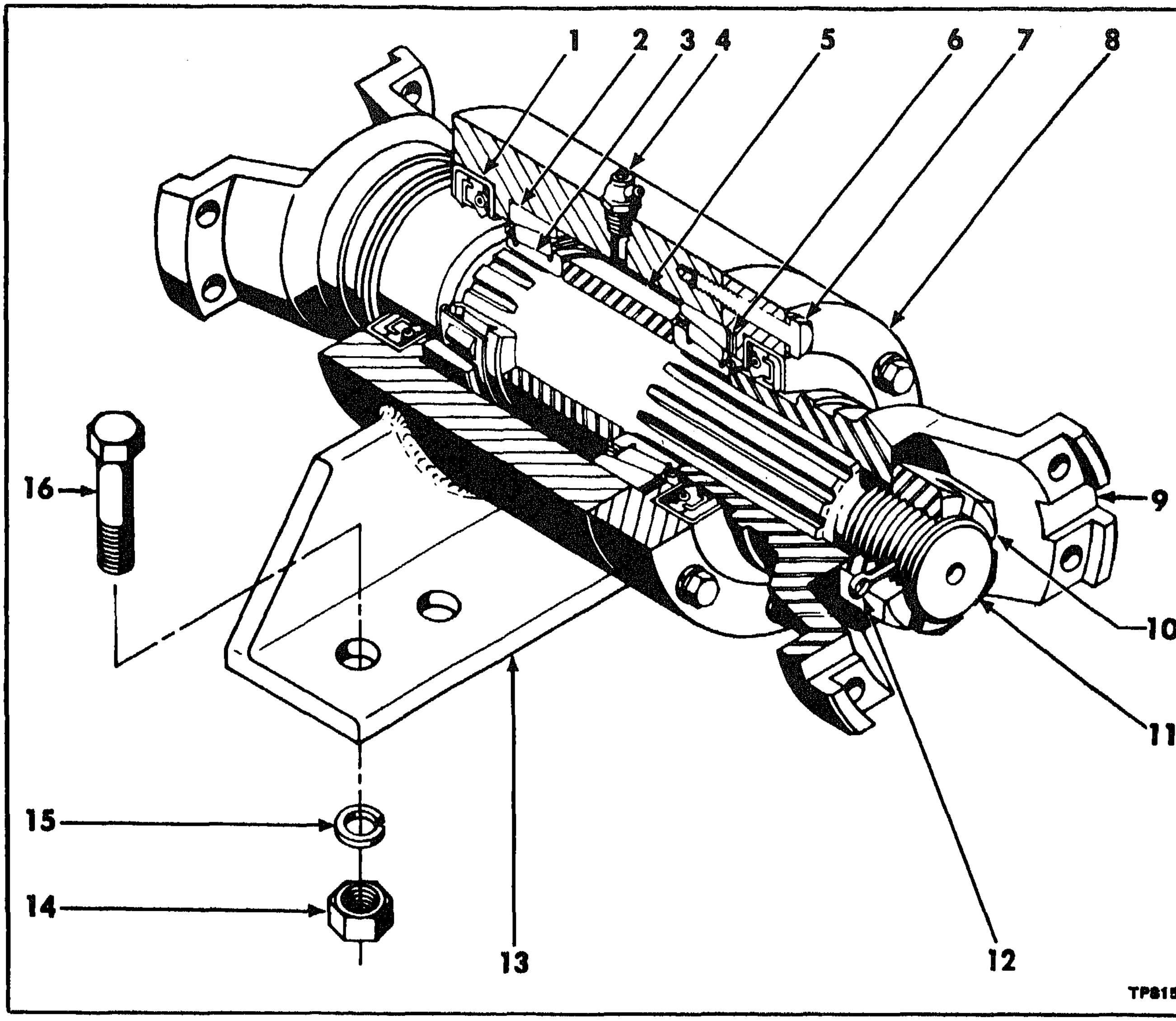
PILLOW BLOCK DISASSEMBLY

Refer to pillow block illustration for identifiication of parts.

Clamp pillow block assembly in a machinist's vise. Remove cotter pin (12) and nut (10) from both ends of shaft (11). Using a puller, pull companion flange yoke (9) from both ends of shaft (11). Loosen and remove capscrews (7) and lockwashers from cover plate (8). Lift off cover plate (8) and shims (6).

PILLOW BLOCK ASSEMBLY





PILLOW BLOCK ASSEMBLY

Item	Part No.	Description	No. Req'd.
A	2059464	Pillow Block Assy. (Incl. Items 1 thru 16)	1
1	2006216	Seal	2
2	2059385	Cup, Bearing	2
3	2059384	Cone, Bearing	2
4	2062146	Fitting, Relief	1
4A	2062147	Fitting, Grease (N.I.)	1
5	2059380	Spacer	1
6	2059471	Shim	AR
6	2059472	Shim	AR
6	2059473	Shim	AR
7	2031480	Bolt	6
7A	2031391	Washer, Lock	6
8	2059377	Plate, Cover	1
9	2059383	Yoke	2
10	2006208	Nut	2
11	2058126	Shaft, Drive	1
12	2006212	Key, Cotter	2
13	2059424	Support Assy.	1
14	2041073	Nut	4
15	2031395	Washer, Lock	4
16	2031562	Bolt, Pillow Block to Frame	4

AR As Required

(N.I.) Not Illustrated

Lift out shaft assembly (11) with bearing cones (3) assembled. Remove top cup (2) from top bearing cone (3). Using a puller, pull bearing cones (3) from shaft (11). Remove bottom cup (2) from bore of housing (13).

Turn cover plate (8) face down and drive out seal (1) from cover plate. Be careful. Do not damage the inner wall of the cover plate. Remove bottom seal (1) from housing (13) in same manner.

PILLOW BLOCK INSPECTION

Refer to pillow block illustration for identification of parts.

Wash all parts in clean mineral oil solvent. Dry parts thoroughly and lay them on a clean surface. Never spin dry bearings using compressed air.

Lubricate the roller bearings with light oil and check them for freeness of rollers, pits, broken rollers or excessive wear. Check the cups for wear or pits. Replace both parts if either is damaged.

Inspect shaft for wear, nicks, scoring and roughness. Replace if necessary.

Inspect housing bore for scoring and roughness. Remove any roughness from the machined surface. Replace housing if roughness cannot be corrected.

Lubricate all parts with a light film of oil prior to reassembly.

REASSEMBLY OF PILLOW BLOCK

Press bearing cone (3) on one end of shaft (11) until bearing cone bottom is located just below the splines of the shaft. Slip special spacer over end of shaft (11) and install nut (10) on threads of shaft. Draw nut down on spacer hand tight.

Turn shaft (11) over and slip spacer (5) onto shaft (11) until it bottoms against bearing cone (3). Press bearing cone (3) on shaft until it bottoms against spacer (5). Slip special spacer over shaft and install nut (10) hand tight on shaft (11).

NOTE: Special spacers may be made from tubular stock machined to proper dimensions shown in Fig. 28. This is not necessary if bearing cones (3) and spacer (5) are centered on shaft (11) equal distances from shaft ends.

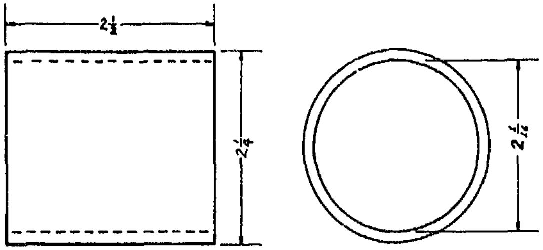


Fig. 28. Special Spacers

INSTALLATION OF OIL SEAL

Oil seals should be first soaked in light oil for a period of at least four hours prior to installation.

Press oil seals (1) in cover plate (8) and pillow block housing (13). Install seals with the side marked "outside" outside. Incorrect seal installation will react as if old seal has been reinstalled.

To facilitate reassembly of pillow block housing and shaft assembly, clamp the pillow block housing in a machinist's vise, being certain housing is held securely.

Position housing so that the tapped holes are facing up. Press cup (2) into housing bore with taper up. Lubricate bearing cones with light oil before reassembly. Pass shaft assembly (11) with bearing cones (3) installed through bore of pillow block, bottoming on cup (2).

Press outer cup (2) over shaft (11) into housing bore. Rotate shaft assembly (11) in housing checking for free rotation and presence of binding.

Install one each of shims (6) .004, .006 and .015 over shaft (11).

Place cover plate (8) with seal (1) installed over end of shaft (11). Properly align bolt holes in cover plate with holes in housing. Do not disturb position of shims as shims pass into cover plate.

Install two capscrews (7) and lockwashers in holes 180° apart. Tighten cap screws to 18 lbs. ft. torque.

With a plastic hammer, strike shaft assembly from both top and bottom to insure bearings have seated themselves correctly.

To check preload on pillow block bearings, wrap a piece of string securely around shaft (11) several times. Attach a pound scale to other end of string and pull off in a straight line. The rotating torque (not starting torque) must be 0 pounds.

Add additional shims under coverplate to increase bearing preload and remove shims to decrease preload. Obtaining correct preload on pillow block bearings will increase pillow block life.

Install remaining capscrews and lockwashers in coverplate and torque to 18 lbs. ft. torque.

Remove nut (10) and special spacer from shaft (11). Lubricate seal journal of companion flange yoke (9) with a light coat of grease.

Press companion yoke (9) on end of shaft (11). It may be necessary to tap yoke with a plastic hammer to insure proper seating of the yoke in the seal.

Install nut (10) on end of shaft. Tighten securely. Insert cotter pin (12) in hole in shaft. Bend end of cotter back over center of pillow block shaft.

Remove pillow block from vise and rotate it 180° and reposition in vise. Install companion flange yoke (9), nut (10) and cotter pin (12) in the same manner as the other end.

Rotate shaft in pillow block several times to insure there is no presence of binding. The shaft will now turn harder than before the yokes were installed. This is caused by the pressure of the seals against the seal journal of the flange yoke.

Remove pillow block from vise. Install special lube fitting in pillow block housing. Using a hand grease gun, lubricate pillow block until grease appears in fair quantity from top of lube fitting. Install special breather.

CAUTION: Do not over-lubricate.

Install pillow block assembly in machine. Tighten mounting bolts securely.

Assemble front and rear propeller shafts to pillow block using only special heat treated capscrews provided.

Tighten capscrews to 95 lb. ft. torque, dry thread.

BALL SLIP JOINT OVERHAUL

REMOVING BALL SLIP JOINT FROM MACHINE

Refer to the ball slip joint illustration for identification of parts.

CAUTION: Before attempting to remove the ball slip joint from the machine, install the safety links between the frame sections of the machine. (See Fig. 5.)

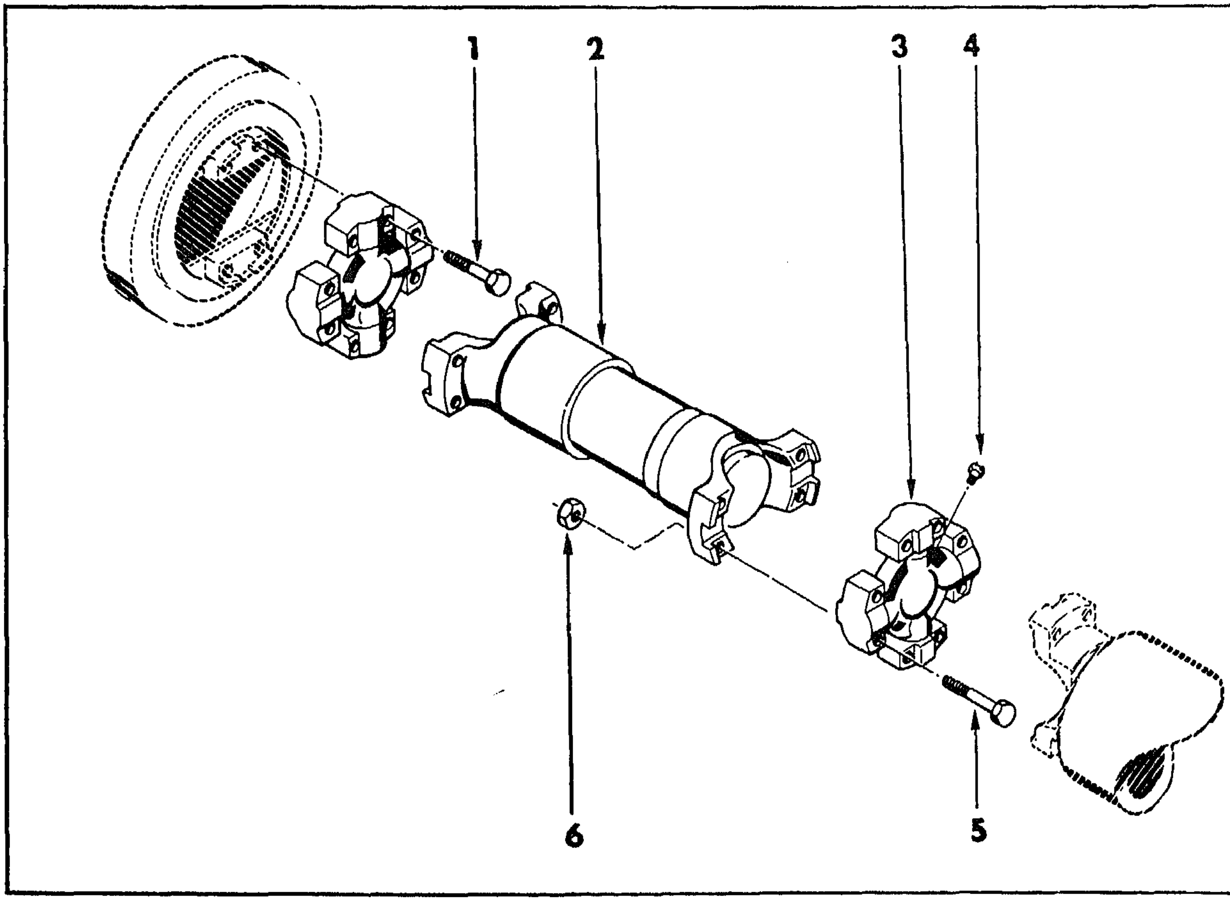
Disconnect the mounting bolts, nuts and lockwashers from the transmission brake drum and the pillow block assembly. Be careful. Do not let the slip joi causing unnecessary damage.

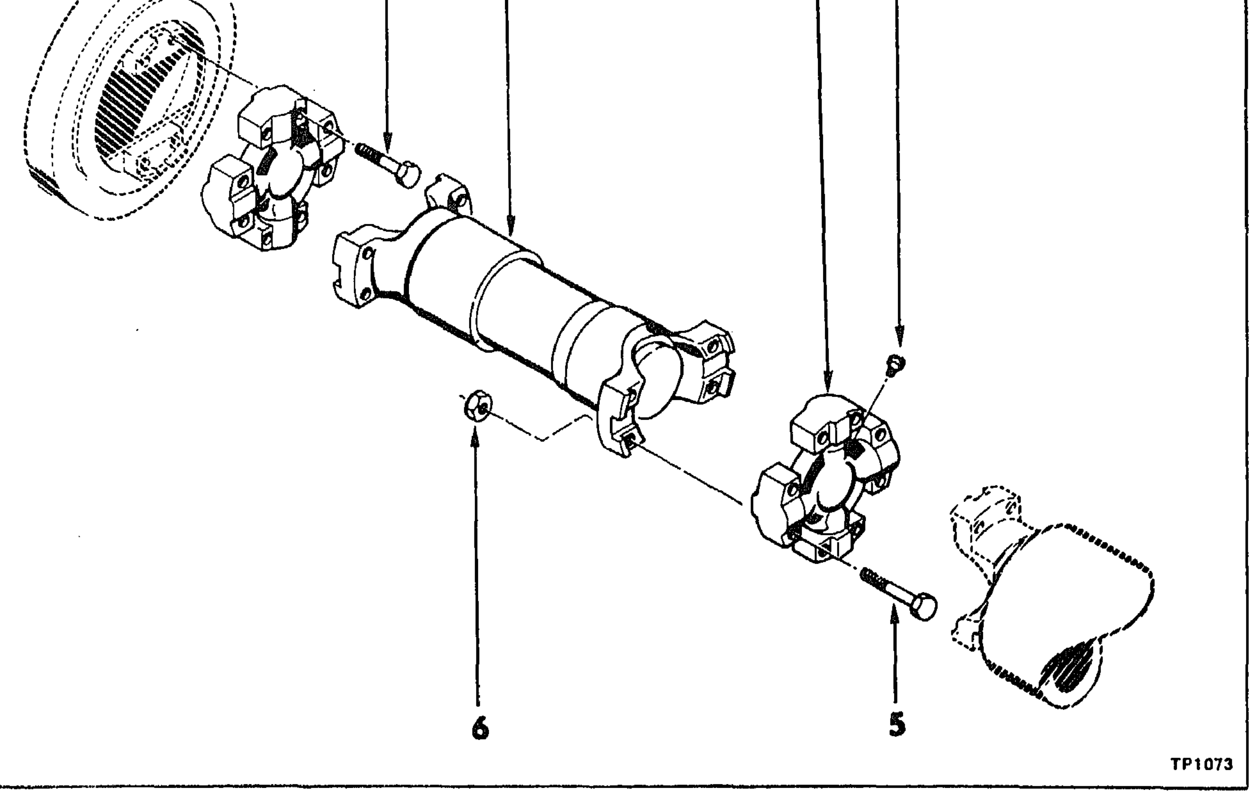
Move the slip joint to a suitable location for d bly.

BALL SLIP JOINT DISASSEMBLY

Loosen and remove the capscrews (1), nuts lockwashers securing the spider and bearings (both ends of the slip joint. Remove spider and assemblies from both ends. Lay aside.

BALL SLIP ASSEMBLY



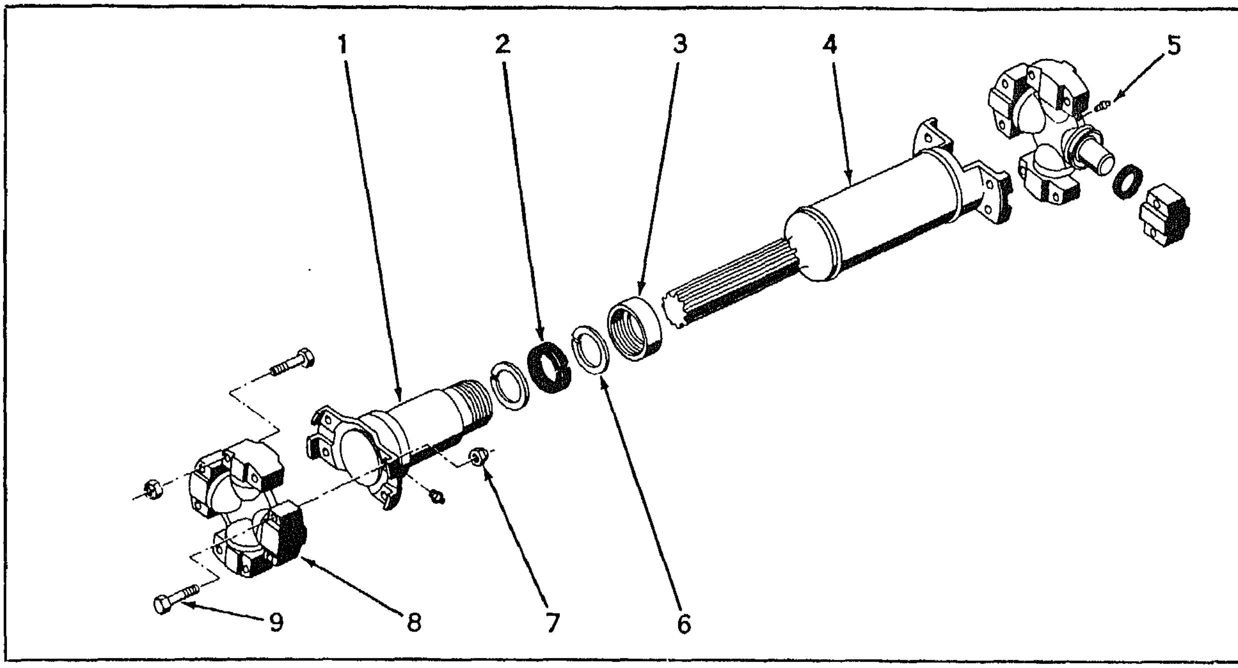


BALL SLIP ASSEMBLY

(From Transmission to Pillow Block)

Item	Part No.	Description	No. Req'd.
A	2067708	Shaft Assy., Prop (Incl. Items 1 thru 6)	1
1	2034372	Capscrew	8
1A	2031393	Washer, Lock (N.I.)	4
2	6952006	Yoke & Shaft Assy.	1
3	6951148	Cross & Bearing Assy.	2
3A	2034365	Shield, Dust (N.I.)	8
4		Plug	2
5	2034372	Capscrew	8
6	2033517	Nut, Jam	12

Not Illustrated



PROPELLER SHAFT ASSEMBLIES

FROM ENGINE TO TRANSMISSION

Item	Part No.	Description	No. Req'd.
A	2067742	Shaft Assy., Propeller (5CL) (Consists of Items 1 thru 10)	1
1	6950018	Yoke Assy., Slip	1
2	6950021	Washer, Felt	1
3	6950020	Retainer, Felt	1
4	6951317	Tube Assy.	1
5	2050894	Fitting, Grease	2
6	6950019	Washer, Retainer	2
7	2033515	Nut	16
8	6951973	Spider & Bearing Assy.	2
9	2034888	Capscrew	16
10	2034880	Plug, Pipe (N.I.)	1

FROM PILLOW BLOCK TO FRONT AXLE

Item	Part No.	Description	No. Req'd.
A	2067744	Shaft Assy., Propeller (7CL) (Consists of Items 1 thru 11)	1
1	6951979	Yoke Assy., Slip	1
2	6951982	Washer, Felt	1
3	6952005	Cap, Dust	1
4	6951978	Tube Assy.	1
5	2050894	Fitting, Grease	2
6	6951891	Washer	2
7	2033517	Nut	16
8	6951980	Spider & Bearing Assy.	2
9	2034372	Capscrew	16
10	2041506	Felt, Retainer (N.I.)	1
11	2034880	Plug, Pipe (N.I.)	1

FROM TRANSMISSION TO REAR AXLE

Item	Part No.	Description	No
A	2067743	Shaft Assy., Propeller (6CL) (Consists of Items 1 thru 10)	
1	6951975	Yoke Assy., Slip	
2	2034879	Washer, Felt	
3	2034882	Cap, Dust	
4	6951974	Tube Assy.	
5	2030224	Fitting, Grease	
6	2034877	Washer, Felt Retainer	
7	2033515	Nut	
8	6951976	Spider & Bearing Assy. (Incl. Item 3 & 8A)	
8A	6951977	Washer, Retainer & Seal	
9	2034888	Capscrew	
10	2034878	Felt, Retainer (N.I.)	

(N.I.) Not Illustrated

Because of fire hazards and insurance regulations, we do not recommend gasoline or any other volatile solvent such as naphtha, benzene, etc. Less flammable fluids such as kerosene or mineral spirits should be used. Do not use a caustic solution. After drying thoroughly with a clean cloth, lay parts on clean, lint-free surface for inspection.

n all parts in solvent before inspecting.

ck each disassembled part for wear, cracks or pitting would render them unfit for future use.

BALL SLIP REASSEMBLY

Install spider and bearings and tighten mounting to 95 lbs. ft. torque dry thread.

Lubricate ball slip joint as directed in the Lubrication Section of this manual.

CAUTION: Do not over-lubricate. Over-lubricating will cause an out of balance condition thus causing unnecessary wear.

Assemble ball slip assembly to machine using only special heat-treated capscrew. Tighten to 95 lbs. ft. torque dry thread.

The brakes on this machine are actuated by an air-over-hydraulic system. The brake system components consist of a compressor, a two section air reservoir, a pressure gauge, selector valve, foot pedal controlled dual brake valve, two power cluster assemblies, four wheel brake hydraulic cylinders, governor, and a safety valve. Connecting lines, hoses, and fittings complete the system. Regular inspections of brake system parts will increase assurance that this system will remain in top operating condition.

The distance the brake pedal is depressed determines the amount of air pressure delivered to the brake power cluster which, in turn, determines the braking force. The best stop is obtained when the brake pedal is depressed firmly to furnish the maximum amount of brake force the machine speed and load will permit, then gradually released as speed decreases. As the stop is completed, there should be only enough air pressure in the power cluster to hold the machine stationary. Applying the brakes lightly at first, then harder as speed decreases, results in a rough stop. Never waste air by pumping the brakes. Frequent and repeated light applications may exhaust air from reservoirs faster than it may be replaced by the compressor. Depress the brake pedal fully only in cases of emergency. Always keep in mind that the most effective braking is done just before the tires slide, regardless of the surface or condition of the working area.

THERE MUST BE AT LEAST 60 POUNDS OF AIR PRESSURE IN THE BRAKE SYSTEM BEFORE THE MACHINE IS MOVED.

Periodically observe the instrument panel brake air gauge (Fig. 3) while operating. If the air pressure drops to a low point (below 60 pounds), stop the machine and correct the trouble.

DO NOT USE THE SERVICE BRAKE SYSTEM TO HOLD THE MACHINE WHEN PARKED. EITHER BLOCK THE WHEELS OR APPLY THE PARKING BRAKE AND LOWER THE FORK.

TESTING BRAKE SYSTEM FOR SERVICEABILITY

Drain reservoir. Charge air brake system. Open both drain valves on the dual section air reservoir. Close drain valves after system has been completely drained of all air and condensation. Refer to Fig. 102.

Pressure build-up test. Run engine at fast idle; time required to raise air pressure from 90 to 120 pounds should not exceed 1 minute.

Check power cluster stroke indicator travel. Adjust if stroke is excessive. (See Power Clusters.)

1. Drain

Fig. 102. Air Reservoir — Showing Drain Valves

Governor setting test. Run engine. Governor should cu out, stopping further compression at 90 to 120 pound dash gauge pressure. Reduce air pressure by series o brake applications. Governor should cut in resumin compression at 75 to 80 pounds.

Leakage tests. Run engine until governor cuts out. Sto engine. With brakes released, dash gauge pressure dro should not exceed 2 pounds per minute. With brake fully applied, pressure drop should not exceed 3 pound per minute. Check all system components if leakage i either test is excessive. See Trouble Shooting table.

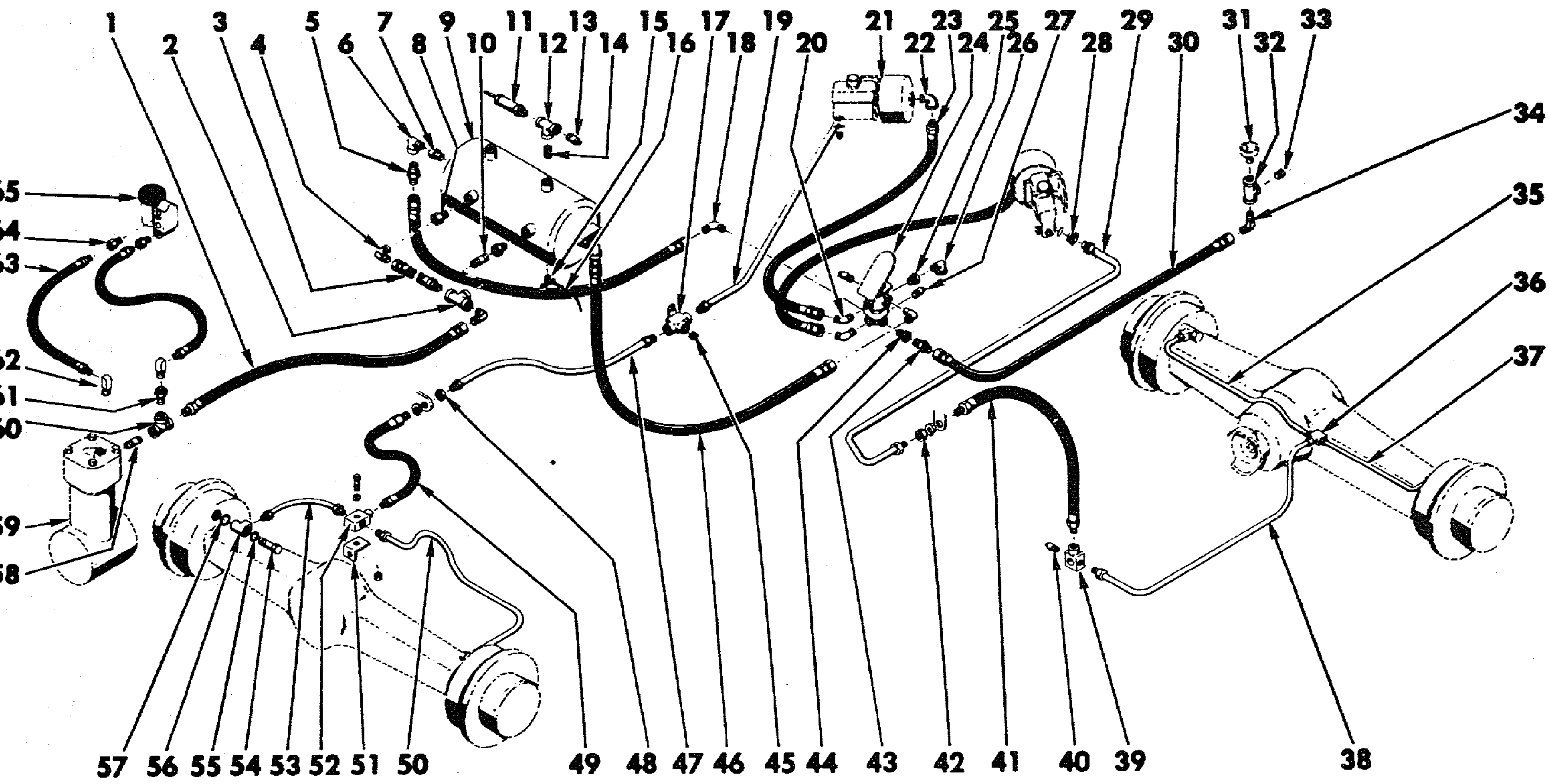
Operating tests. Connect accurate test gauge in brak valve delivery line. Fully charge brake system. Depre pedal fully. Test gauge pressure should approximatel equal dash gauge pressure.

Check for quick application and release of all brake With air reservoirs fully charged and in normal opera ing condition, operate machine and check for bral effectiveness at various speeds. Sluggish, spongy bra ing may be due to air in the hydraulic brake system. necessary, bleed the brake hydraulic system.

TROUBLE	PROBABLE CAUSE
Insufficient brakes	Brakes need adjustment or relining. Air in brake hydraulic system. Low air pressure in brake system (below 80 pounds). Brake valve delivery pressure below normal. Brake fluid supply low in power clusters.
Brakes apply too slowly	Brakes need adjustment. Low air pressure in brake system (below 80 pounds). Brake valve delivery pressure below normal. Air in brake hydraulic system. Excessive leakage with brakes applied. Restricted hydraulic tubing or hose line. Restricted air tubing or hose line. Brake fluid supply low in power clusters.
Brakes release too slowly	Brakes need adjustment. Brake valve not returning to fully released position. Restricted tubing or hose line. Blocked by-pass port in power cluster. Exhaust port of brake valve restricted or plugged. Brake shoe return spring broken.
Neither front or rear brakes apply	No air pressure in brake system. Restricted or broken air tubing or hose line. Defective brake valve.
Front wheel brakes (only) do not apply	Front wheel power cluster has low brake fluid supply or is defective. Restricted hydraulic lines in front wheel system.
Rear wheel brakes (only) do not apply	Rear wheel power cluster has low brake fluid supply or is defective. Restricted hydraulic lines in rear wheel system.
Brakes do not release	Brake linkage binding. Brake valve not in fully released position. Defective brake valve. Restriction in tubing or hose line. Defective power cluster.
Brakes grab	Grease on lining; reline brakes. Brake drum out of round. Defective brake valve. Brake linkage binding. Defective power cluster.

TROUBLE SHOOTING AIR BRAKE SYSTEM (CONT.)

TROUBLE	PROBABLE CAUSE
Uneven brakes	Brakes need adjustment, lubricating or relining.
	Grease on lining; reline brakes.
	Brake shoe release spring broken.
	Brake drum out of round.
	Brake power cluster leaking.
Air pressure will not rise to normal	Defective dash gauge.
	Excessive leakage.
	Governor out of adjustment.
	No clearance at compressor unloading valves.
	Defective compressor.
Air pressure rises to normal too slowly	Excessive leakage.
	No clearance at compressor unloading valves.
	Engine speed too slow.
	Compressor discharge valves leaking.
	Worn compressor.
	Excessive carbon in compressor cylinder head or discharge line.
Air pressure rises above normal	Defective dash gauge.
	Governor defective or out of adjustment.
	Restriction in line between governor and compressor unloader valves.
	Too much clearance at compressor unloader valves.
	Compressor unloading valves stuck closed.
Air pressure drops quickly with engine stopped and brakes released	Leaking brake valve.
	Leaking tubing or hose line.
	Compressor discharge valve leaking.
	Governor leaking.
Air pressure drops quickly with engine stopped and brakes fully applied	Leaking brake power cluster.
	Leaking brake valve.
	Leaking tubing or hose line.
Compressor knocks	Worn or burnt out bearings.
	Excessive carbon deposits in compressor head.
Safety valve "blows off"	Safety valve out of adjustment.
	Air pressure in system above 150 psi.
Excessive oil or water in the brake system	Reservoirs not being drained often enough.
	Compressor passing excessive oil.
Hydraulic system cannot be bled properly	Faulty residual pressure check valve in hydraulic cylinder of power cluster.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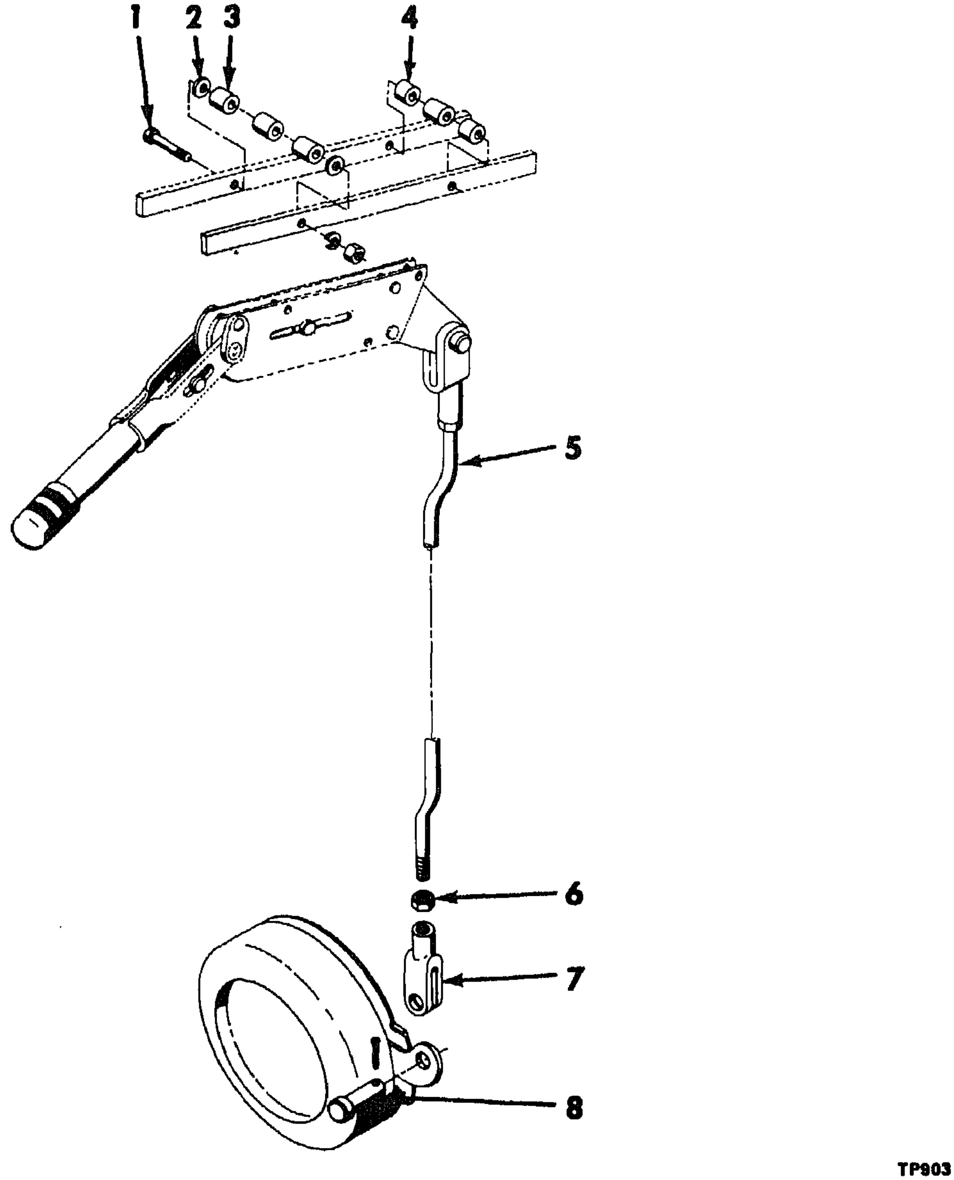
TP1071

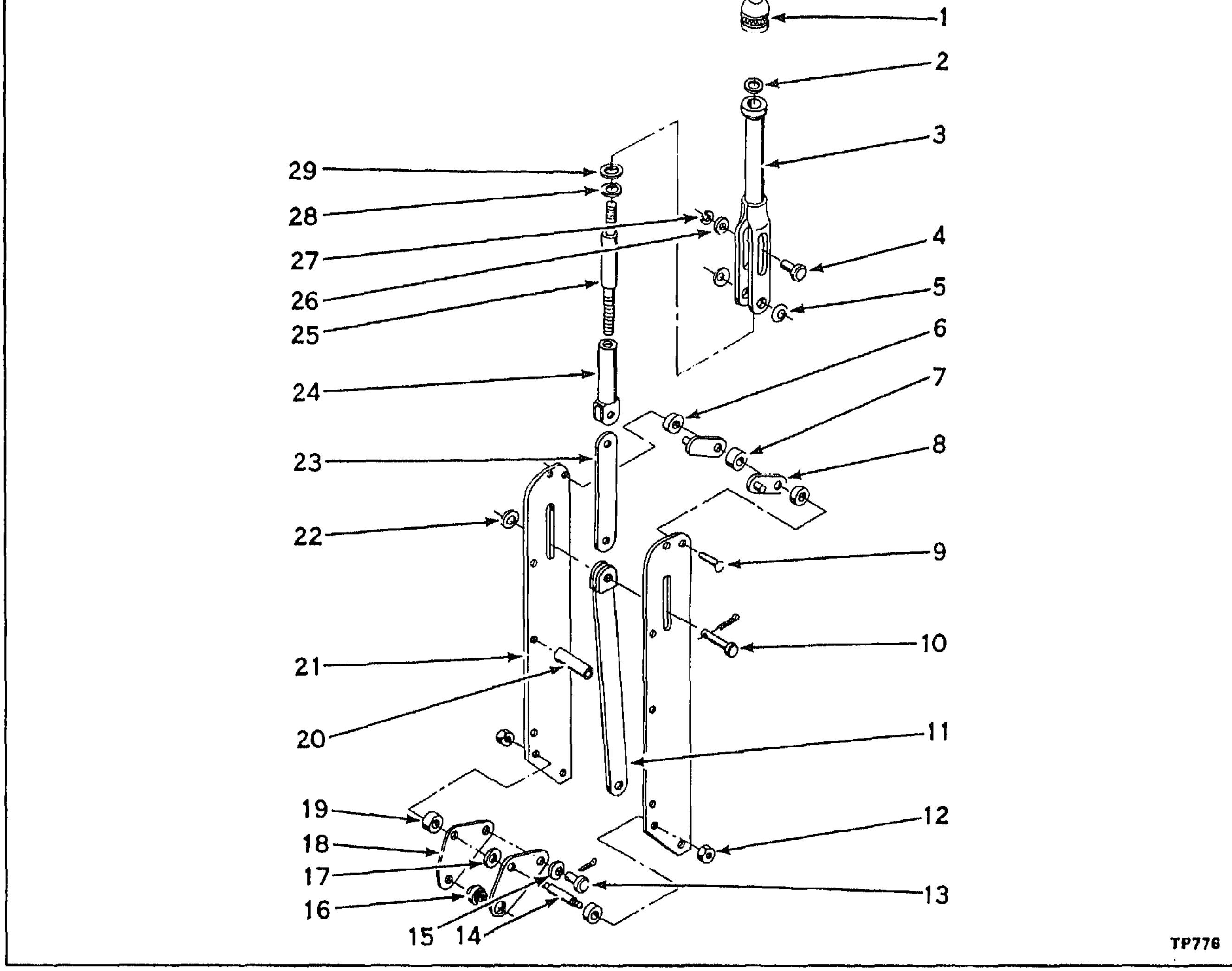
Item	Part No.	Description	No. Req'd.
1	2039544	Hose	1
2	2032313	Tee	1
3	2046556	Hose	1
4	2032011	Elbow, 90°	2
5	2031988	Connector, Straight	2
6	2032294	Elbow	2
7	2053266	Bushing, Reducer	2
8	2054598	Valve, Check	2
9	2059175	Reservoir, Air	1
9A	2031477	Bolt, Reservoir to Bracket (N.I.)	1
9B	2031391	Washer, Lock (N.I.)	4
9C	2032960	Washer, Flat (N.I.)	4
9D	2031617	Nut (N.I.)	4
10	2033499	Nipple	1
11	2034221	Valve, Blow Off	1
12	2032311	Tee	1
13	2033384	Plug, Pipe	2
14	2033448	Nipple, Pipe	1
15	2061742	Cock, Drain	2
16	2061748	Hose	2
17	2032766	Block, Junction	1
17A	2031473	Bolt, Block to Frame (N.I.)	1
17B	2031391	Washer, Lock (N.I.)	1
17C	2032960	Washer, Flat (N.I.)	1
18	2032010	Elbow, 90°	2
19	2067740	Line Assy., Brake	1
20	2031999	Elbow, 45°	2
21	———	Cluster, Power (See Sep. Illus.)	
21A	2031475	Bolt, Cluster to Front Shroud (N.I.)	8
21B	2031391	Washer, Lock (N.I.)	8
21C	2031617	Nut (N.I.)	8
21D	2034328	Plug, Power Cluster	2
21E	2033395	Gasket	2
22	2032294	Elbow, 90°	2
23	2034677	Hose	2
24	———	Valve Assy., Foot (See Sep. Illus.)	
24A	2031453	Bolt, Valve to Floorplate (N.I.)	3
24B	2031390	Washer, Lock (N.I.)	3
24C	2031616	Nut (N.I.)	3
25	2053263	Bushing, Reducer	1
26	2032293	Elbow, 90°	1
27	2033385	Plug, Pipe	2
28	2034330	Fitting, Adapter	2
28A	2033395	Gasket	2
29	2067741	Line Assy., Brake	1
30	2034408	Hose	1
31	———	Gauge, Air Pressure (See Instument Panel)	
32	2032310	Tee	1
33	2033383	Plug, Pipe	1
34	2032007	Elbow, 90°	1
35	2032748	Line Assy., Brake, L.H. Front Axle	1
36	2032766	Tee	1
36A	2031517	Bolt, Tee to Axle (N.I.)	1
36B	2031393	Washer, Lock (N.I.)	1
37	2032747	Line Assy., Brake R.H.	1
38	2059696	Line Assy., Brake Tee to Front Axle	1
39	2032764	Tee	1
39A	2031479	Bolt, Tee to Frame (N.I.)	1
39B	2031391	Washer, Lock (N.I.)	1
39C	2031617	Nut (N.I.)	1
40	2043616	Plug, Tube	1
41	2032768	Hose	1
42	2033519	Nut, Jam	1
42A	2033598	Washer, Lock	1
43	2031985	Connector, Straight	1
44	2053262	Bushing, Reducer	1
45	2043616	Plug	1
46	2059743	Hose	2
47	2059687	Line Assy., Brake	1
48	2033519	Nut, Jam	1
48A	2033598	Washer, Lock	1
49	2032768	Hose	1
50	2059692	Line Assy., Brake	1
51	2040438	Bar, Mount	1
52	2032764	Tee	1
52A	2031479	Bolt, Tee to Axle	1
52B	2031391	Washer, Lock	1
52C	2031617	Nut	1
53	2059690	Line Assy., Brake	1
54	2033394	Bolt, Fitting	4
55	2033395	Gasket	4
56	2033379	Fitting, Brake, 90°	4
57	2012046	Gasket	4
58	2036513	Nipple	1
59	———	Compressor (Furnished with Engine)	
60	2032313	Tee, Pipe	1
61	2033041	Bushing, Reducer	1
62	2033858	Elbow, 90°	2
63	2035611	Hose	2
64	2033022	Connector, Straight	2
65	2046601	Governor	1
65A	2031463	Bolt, Governor to Mount Plate (N.I.)	2
65B	2031390	Washer, Lock (N.I.)	2
65C	2031616	Nut (N.I.)	2

(N.I.) Not Illustrated



PARKING BRAKE AND LINKAGE

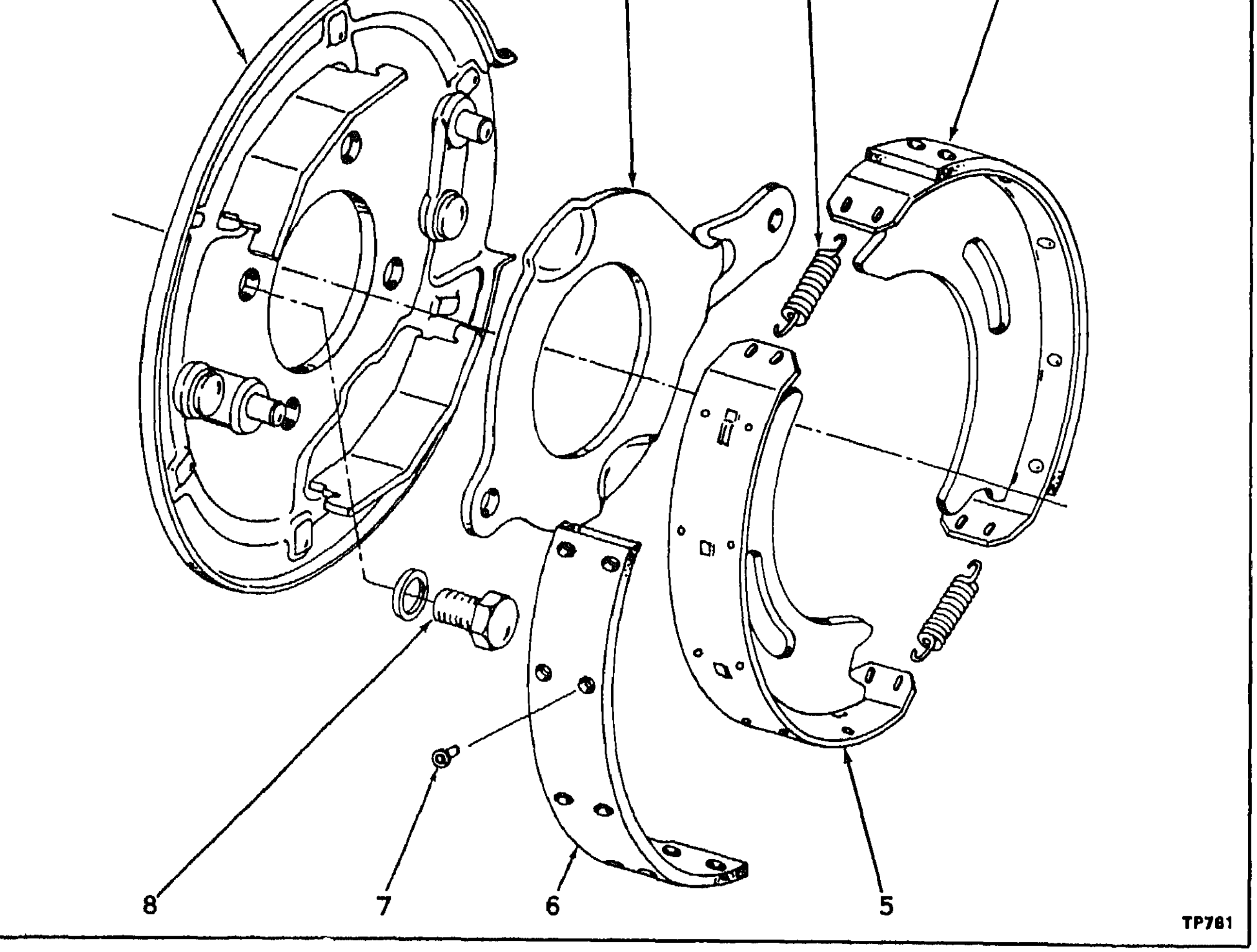
Item	Part No.	Description	No. Req'd.
1	2031461	Bolt, Lever to Hydraulic Tank	2
1A	2031390	Washer, Lock	2
1B	2031616	Nut	2
2	2032959	Washer, Flat (Rear)	2
3	2036978	Spacer	2
4	2040030	Spacer	2
5	2062088	Rod, Threaded, Lever to Parking Brake	1
6	2033517	Nut, Jam	2
7	2031678	Clevis	2
8	2010556	Pin, Clevis	2
8A	2031768	Pin, Cotter	2
9	———	Lever, Parking Brake (See Sep. Illus.)	1



PARKING BRAKE LEVER ASSEMBLY

Item	Part No.	Description	No. Req'd.
A	2038093	Lever Assy., Parking Brake (Incl. Items 1 thru 33)	1
1	6950676	Knob, Adjusting	1
1A	6950674	Ball (N.I.)	1
1B	6950675	Spring (N.I.)	1
1C	6950681	Base, Adjusting Knob (N.I.)	1
1D	6951378	Washer, Spring (N.I.)	1
2	6750336	"O" Ring	1
3	6950723	Body Assy., Lever	1
4	6951983	Pin	1
4A	6950700	Washer, Spring (N.I.)	1
5	———	Washer, Spring (Not Applicable)	
6	6950727	Spacer	2
7	6950688	Spacer	1
8	6950728	Bracket Assy., Pivot	2
9	6950731	Rivet	2
10	6950725	Pin	1
11	———	Link (Not Applicable)	
12	———	Nut (Not Applicable)	
13	6950725	Pin	1
14	6950726	Pin	1
15	———	Washer, Spring (Not Applicable)	
16	6950680	Bushing, Bellcrank	1
17	———	Spacer (Not Applicable)	
18	6950683	Bellcrank	2
19	———	Spacer (Not Applicable)	
20	6950735	Spacer	2
21	6950729	Bracket, Mounting (L.H.)	1
21A	6950730	Bracket, Mounting (R.H.)	1
22	6950686	Ring, Retaining	1
23	6950733	Link	1
24	6950678	Tube Assy., Adjusting	1
25	6950724	Screw, Adjusting	1
26	2036815	Washer	1
27	6950686	Ring, Retainer	1
28	———	Washer (Not Applicable)	
29	6951359	Washer, Spring	1
30	6950734	Spacer (N.I.)	1
31	6950732	Spacer (N.I.)	1

(N.I.) Not Illustrated



PARKING BRAKE ASSEMBLY

m	Part No.	Description	No. Req'd.
	2039397	Brake Assy., Parking (Incl. Items 1 thru 12)	1
	6950114	Lining Kit, Service (Incl. Items 6 & 7)	1
	6950116	Pawl Kit, Service (Incl. Items 9 thru 12)	1
	6950112	Plate Assy., Backing	1
	6950113	Lever, Brake Actuating	1
	2040424	Spring, Brake Release	2
	2040423	Shoe & Lining Assy., Brake (Incl. Items 5 thru 7)	2

Item	Part No.	Description	No. Req'd.
5	———	Shoe, Brake (N.S.S.) (Order Item 4)	2
6	———	Lining, Brake (N.S.S.) (Order Item B)	2
7	6950115	Rivet	20
8	2031536	Bolt, Backing Plate	4
8A	2031394	Washer, Lock	4
9	———	Roller (N.S.S.) (N.I.)	2
10	———	Pawl (N.S.S.) (N.I.)	2
11	———	Bolt (N.S.S.) (N.I.)	2
12	———	Nut, Lock (N.S.S.) (N.I.)	2

S.S.) Not Serviced Separately

I.) Not Illustrated

COMPRESSOR

The air compressor is an integral part of the diesel engine. Refer to Engine Operation and Maintenance for trouble shooting and maintenance information.

BRAKE VALVE

Lubricate roller pin and hinge pin with multipurpose grease after every 50 hours of operation. Each valve has grease fitting installed. Lift boot away from mounting plate and place six drops of engine oil (SAE-20) between mounting plate and plunger after every 50 hours of operation.

Periodically clean exhaust strainer.

When installing brake valve, position the adjusting screw so that it just contacts the bottom of the treadle with the roller resting on the plunger. Tighten the jam nut to hold the adjusting screw in this position.

When overhauling the brake valve, order Repair Kit, Trojan Part No. 6955170 for seals and other service parts. Replace all parts with those in kit.

DASH AIR GAUGE

Every 6 months, check dash gauge with a test gauge known to be accurate.

AIR RESERVOIR

Keep condensation drained. Open both drain valves at the bottom of the air reservoir daily or as frequently as found necessary, depending on operating conditions. Oil and water from the compressor should not be allowed to accumulate in the reservoir. See Fig. 102.

SAFETY VALVE

When reservoir pressure reaches 90 to 120 pounds, pull the exposed valve stem occasionally to permit the valve to "blow off." If valve does not "blow off" when this is done, remove, disassemble and clean. Pressure setting may be raised by turning adjusting screw clockwise or lowered by turning adjusting screw counterclockwise. Always loosen lock nut before adjusting and make certain it is tightened after adjustment is made.

GOVERNOR

When reservoir pressure reaches 90 to120 pounds, the governor stops the further compression of air. When the reservoir pressure is reduced to 80 to 85 pounds, the governor shuts off exhausting air and compression is begun again.

Pressure range and settings should be checked periodically, using an air gauge known to be accurate. To adjust the governor, remove the rubber cover from the top of the governor. Loosen the lock nut and turn the adjusting screw. If air escape pressure is less than 90 psi turn the adjusting screw clockwise. If air escape pressure is above 120 psi, turn the adjusting screw counterclockwise. Tighten the lock nut, install the cover. Both strainers should be removed periodically and cleaned or replaced.

The governor should be periodically checked for leakage at the exhaust port in both cut in and cut out positions.

BRAKE POWER CLUSTER

Check the power cluster for brake hydraulic fluid leaks. Apply the brakes and check for air leaks.

Check the stroke indicator periodically to determine if brake adjustment is required. Before checking, make sure the brake fluid reservoirs are filled.

To check the power cluster stroke, build up normal air pressure in the air reservoir. Depress the brake pedal fully to apply the brakes. At the same time, have an assistant (positioned under the loader) measure the travel of the stroke indicator of the power cluster (Fig. 103). Normal travel is to 1¼ inch. Greater travel indicates the need for brake adjustment. The power cluster at the right side of the machine is associated with the front wheel brakes. The power cluster at the left side of the machine is associated with the rear wheel brakes.

NOTE: Excessive travel of the stroke indicator may be caused by air in the brake hydraulic system. If braking is spongy, and if brake shoe adjustment fails to correct the excessive travel of the stroke indicator, bleed the brake system to remove any entrapped air.

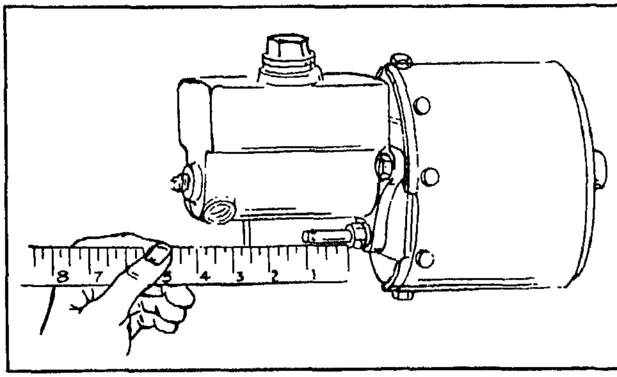


Fig. 103. Checking Brake Adjustment at Power Cluster

POWER CLUSTER REMOVAL

Thoroughly clean the area around the power cluster to prevent the entry of dirt into air and hydraulic lines.

Disconnect the air and hydraulic lines from the power cluster.

Remove the bolts and lockwashers that secure the power cluster to the front shroud; remove the power cluster.

POWER CLUSTER DISASSEMBLY

Refer to the Power Cluster illustration for identification of parts.

Clean the exterior of the power cluster with an oil solvent or kerosene. Dry thoroughly. Take care to prevent solvent from entering hydraulic cylinder.

Remove the screws (3) and lockwashers that secure the shell (2) to the head assembly (9). Pull off the shell.

Remove the piston (5), return spring (7), and boot (8). Pull the piston cup (4) and wiper (6) from the piston.

Unscrew the stroke indicator (16) to remove it.

Use an awl to pry the filter screen (10) from the head (9). Push out the filter (11) and second screen.

Remove lock ring (23) that secures the piston stop plate (22) from the housing (14); remove the plate and slide out the piston assembly and spring (18).

Remove the primary cup (19) and secondary cup (21) from the piston (20).

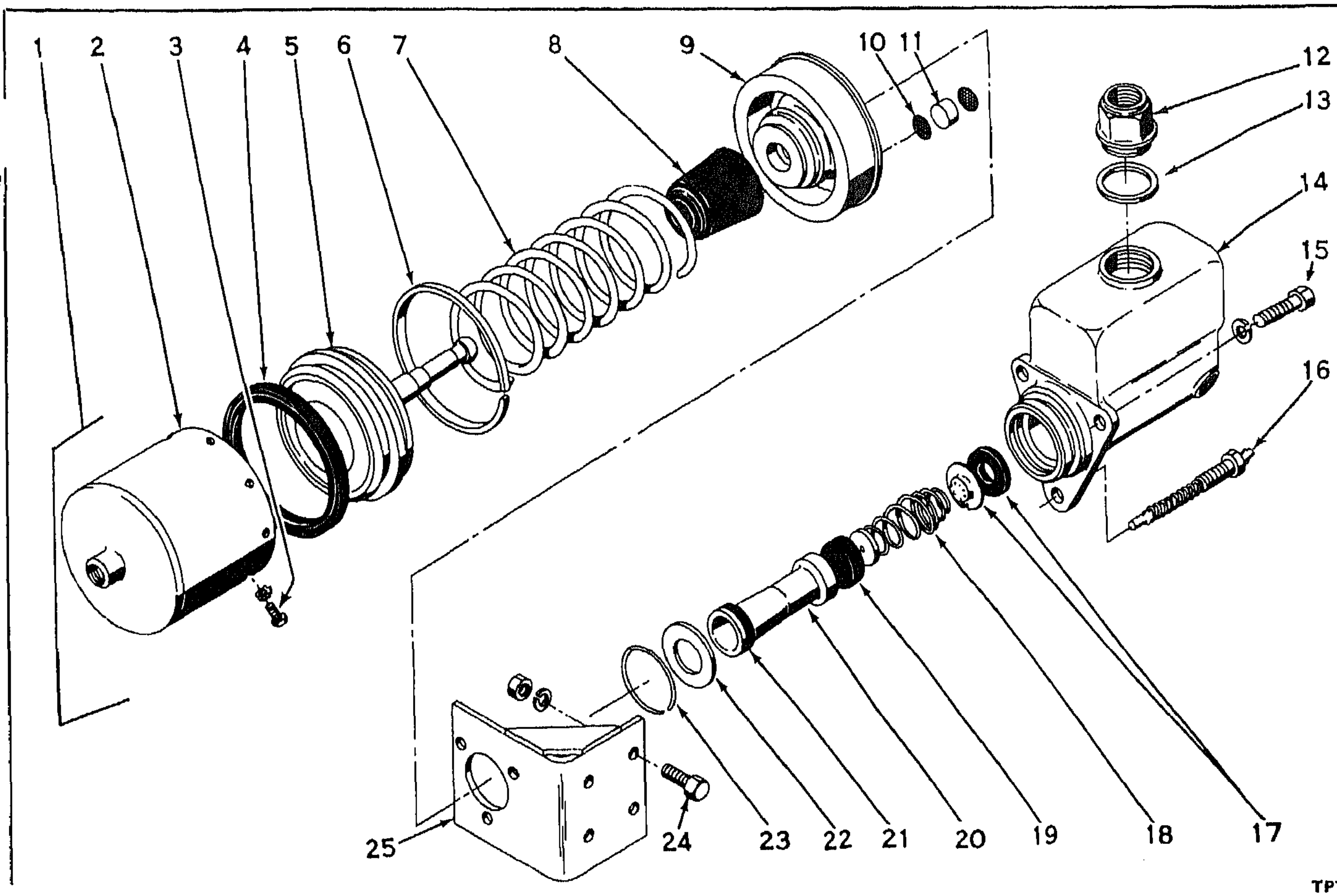
Remove the parts of the check valve (17) from the housing (14).

POWER CLUSTER CLEANING AND INSPECTION

Clean the air ports of the power cluster with cleaning solvent. Dry with compressed air.

Clean hydraulic cylinder parts with denatured alcohol or hydraulic brake fluid. Do not use mineral solvents, since they will deteriorate rubber parts. The cylinder may be steam cleaned to remove all loose dirt and reservoir sediment. Do not attempt to clean the bypass part with a stiff wire, since it may enlarge or burr the part.

POWER CLUSTER ASSEMBLY



Inspect the air cylinder shell for dents, scores, or scratches that could damage the lip of the piston cup.

Inspect the air cylinder piston and rod for tight assembly. The rod must be at right angles to the piston.

Inspect the air cylinder piston cup for wear, swelling, or softness. Replace if damaged.

Inspect the air cylinder boot for cracks and deterioration. Replace if faulty.

Inspect spring for rust, corrosion, and distortion. Replace springs which have taken a "set."

Inspect the hydraulic cylinder for scoring, grooves, or other damage of the cylinder walls. Polish with a crocus cloth or hone with a conventional hone set, following the manufacturer's instructions. Clean thoroughly with denatured alcohol after honing.

The inside diameter of the cylinder must not exceed the nominal size by more than .007 inch. Remove any burrs from the bypass port after honing.

Inspect the hydraulic cylinder piston for scratches and eccentricity. Replace a damaged piston.

Replace hydraulic piston primary and secondary cups if they are worn, swollen, or soft.

POWER CLUSTER REASSEMBLY

Refer to Power Cluster illustration for identification of parts.

Install the parts of the check valve (17) and the spring (18) in the housing (14). Install the primary and secondary cups (19 and 21) on the hydraulic cylinder piston (20). Lubricate the piston parts and the bore of the hydraulic cylinder with clean hydraulic fluid before assembling.

Install the piston in the hydraulic cylinder of the housing. Secure by installing the piston stop plate (22) and lock ring (23).

Soak the wiper (6) in SAE-10 engine oil before assembling. Install the wiper and piston cup (4) on the piston.

Install the screen (10), filter (11), and second screen in the head (9).

Install the boot (8) on the piston so that the lip engages the groove at the air piston.

Position the spring (7) and piston (5) on the head (9). Position the shell carefully over the piston and secure to the head with screws (3) and lockwashers.

Insert a drift into the air intake part of the shell and force the piston through a full stroke. At the end of the stroke the boot should engage the groove in the cylinder head.

Install the stroke indicator (16).

Position the air and hydraulic parts of the power cluster on the angle bracket; secure together with bolts (3) and lockwashers.

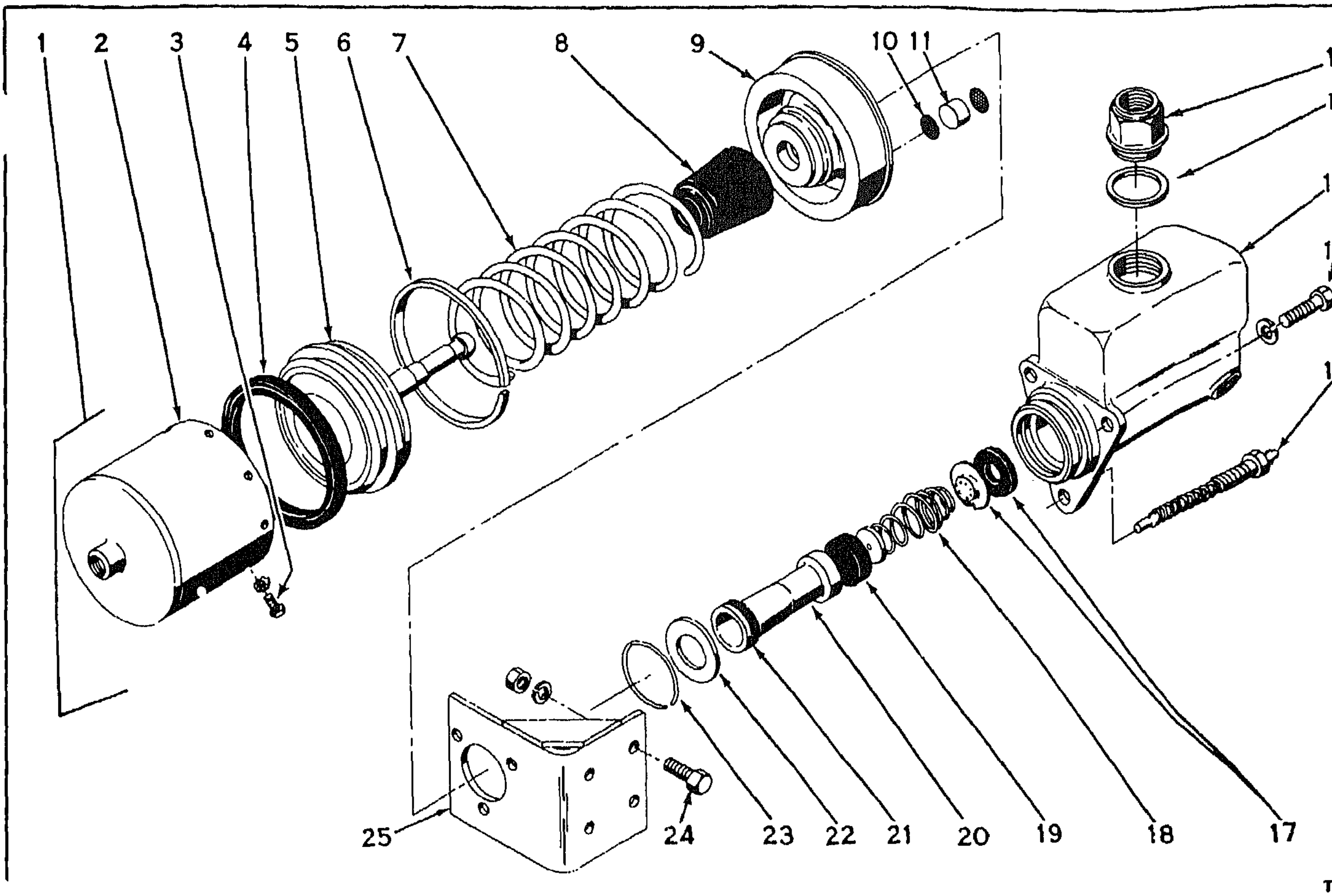
POWER CLUSTER INSTALLATION

Position the angle bracket of the power cluster on the frame; secure with bolts, nuts, and lockwashers.

Connect the air and hydraulic lines to power cluster.

Fill the hydraulic reservoir of the power cluster with hydraulic brake fluid. Start the engine to build up air pressure. Bleed the brakes as directed in the Brake Section. (See Index.) Check for air and hydraulic leaks and for proper brake application.

NOTE: Each time a power cluster is rebuilt, we recommend the power clusters be rebuilt in pairs.



POWER CLUSTER ASSEMBLY

(Two power clusters used per machine. Quantity shown is for one.)

Item	Part No.	Description	No. Req'd.
A	2048254	Power Cluster Assy. (Incl. Items 1 thru 27)	1
B	6950217	Repair Kit, Power Cluster (Incl. Items 4, 6, 8, 17, 19 & 20)	1
C	6951277	Cylinder Assy., Master (Incl. Items 12, 13, 14 & 17 thru 23)	1
1	6951267	Cylinder Assy., Air (Incl. Items 2 thru 11A & 15 thru 16)	1
2	6951268	Shell	1
2A	2033040	Reducer, Pipe (N.I.)	1
3	2031449	Screw, Cap	8
3A	2035542	Washer, Lock	8
4	6951269	Cup, Piston	1
5	6951221	Piston & Rod Assy.	1
6	6951270	Wiper	1
7	6951272	Spring, Piston Return	1
8	6951271	Boot	1
9	6951273	Head Assy. (Incl. Items 10 thru 11A)	1
10	6951274	Screen	2

Item	Part No.	Description	No. Req'd
11	6951275	Filter	1
11A	6951276	Retainer (N.I.)	1
12	6951286	Plug, Filler	1
13	2040808	Gasket	1
14	6951278	Housing	1
15	2037617	Bolt	2
15A	2031391	Washer, Lock	3
16	6951223	Indicator, Stroke	1
17	6951279	Valve, Check	1
18	6951280	Spring, Piston Return	1
19	6951281	Cup, Primary	1
20	6951282	Piston Assy. (Incl. Item 21)	1
21	6951283	Cup, Secondary	1
22	6951284	Plate, Piston Stop	1
23	6951285	Ring, Lock	1
24	2031475	Screw, Cap	4
24A	2031391	Washer, Lock	4
24B	2031371	Nut	4
25	6951288	Bracket, Mounting	1
26	6951290	Plate, Identification (N.I.)	1
27	6951289	Pin, Identification Plate (N.I.)	2

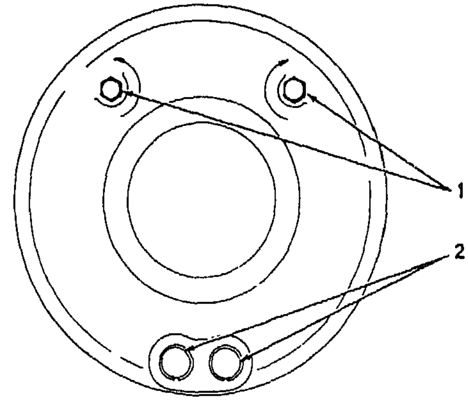
To assure proper operation of the hydraulic brake system, it must be completely free of air bubbles. After overhaul of components or after any other condition that could have allowed the entry of air into the hydraulic system, the associated brake system must be bled. The necessity for bleeding is indicated by excessive travel of the power cluster stroke indicator when the brake is applied with all brakes properly adjusted. Air in the brake system can be caused by extremely low fluid in the reservoir of the power cluster or by faulty piston cups in the wheel cylinder or in the hydraulic cylinder.

NOTE: Maintain a full supply of clean brake fluid in the hydraulic reservoir of the power cluster while bleeding the brake system. The left power cluster is associated with the rear brakes. The right power cluster is associated with the front brakes.

Install a brake bleeder hose approximately 15 inches long on the brake bleeder screw at one of the associated wheel cylinders. Place the other end of the hose in a glass jar containing a small amount of brake fluid. Start the engine and build up air pressure in the brake air reservoir. Loosen the bleeder screw and have a helper slowly depress the brake pedal. Tighten the bleeder screw before the brake pedal is released. Bubbles rising in the fluid in the jar indicate air in the system. Repeat the procedure until there is no sign of air bubbles being pumped from the bleeder screw. Tighten the bleeder screw and remove the hose.

Repeat the procedure for the remaining wheel of the associated system to assure that the system is free of air. After bleeding, make sure the fluid is at the required level in the fluid reservoir of the power cluster.

NOTE: Fluid pumped from the brake system during the bleeding procedure should be discarded. Fill the power cluster with clean brake fluid during bleeding to prevent additional entry of air due to a low fluid supply in the reservoir.



1. Brake shoe adjusting cams
2. Anchor pins (not adjustable)

Fig. 105. Brake Shoe Adjustment

TROUBLE SHOOTING AIR BRAKE SYSTEM

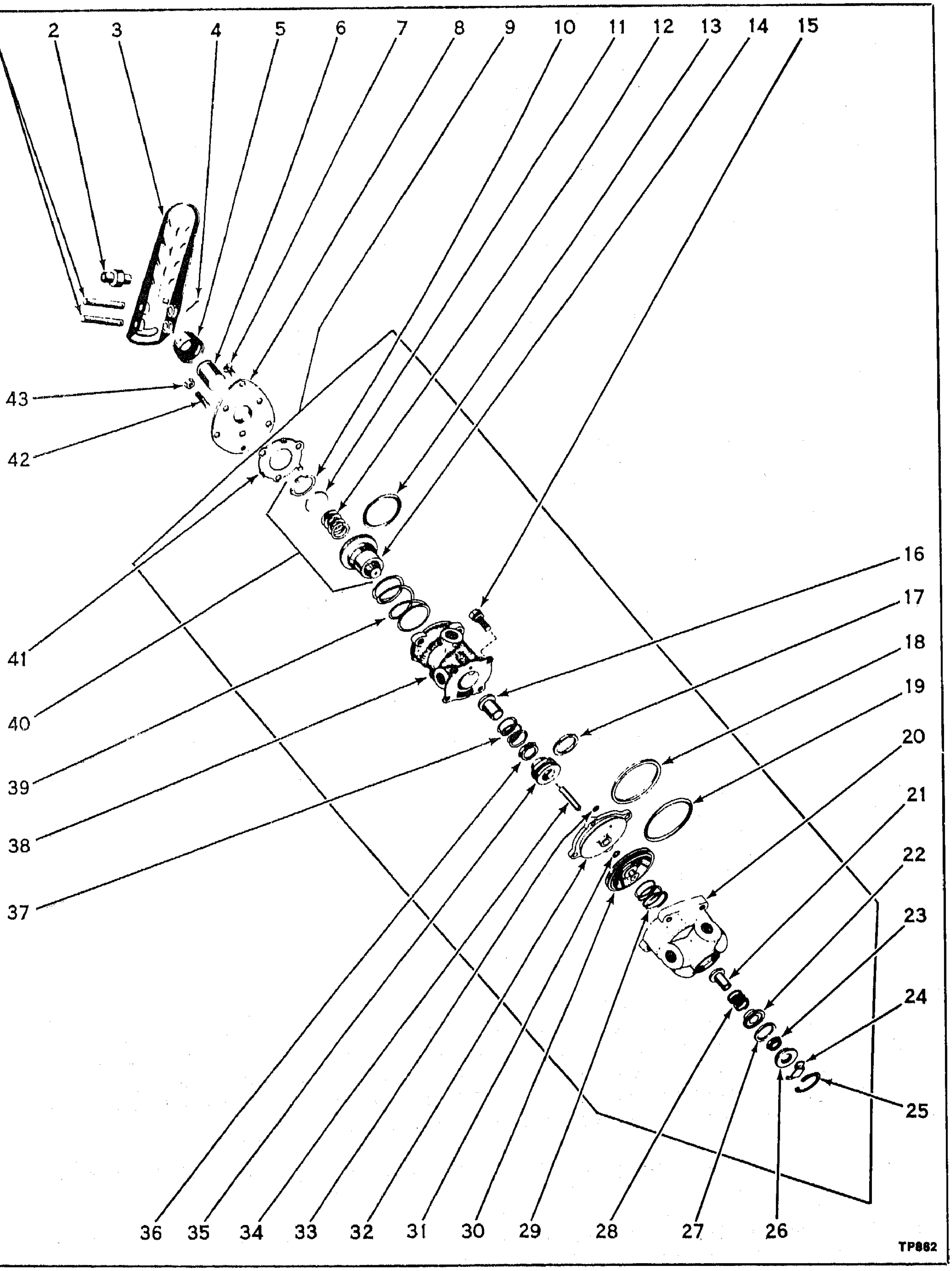
NOTE: When trouble shooting the brake system, the trouble is most easily localized by determining if both or either front or rear brakes are affected. From the air reservoir to the brake treadle valve, the front and rear brake systems use the same operating components. From the brake treadle valve to the wheels, the front and rear components are separate.

BRAKE ADJUSTMENT

Block rear wheels and jack up front wheels until they are free to rotate. Turn one adjusting cam in the direction shown in figure 105 until the brake lining is firmly pressed against the drum, preventing wheel rotation. Then back off the cam while rotating the wheel until the wheel is free to rotate without any brake drag. Repeat the procedure for the second cam to complete the adjustment for one wheel. Adjust the opposite wheel in the same manner.

NOTE: Since the differentials are limited slip type, both wheels of the same axle must be jacked up.

Block the front wheels and jack up the rear wheels. Perform rear wheel brake adjustment using same procedure as above.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DUAL BRAKE VALVE

Item	Part No.	Description	No. Req'd.
A	2057708	Valve Assy., Dual Brake	1
B	6955170	Kit, Valve Repair (Incl. Items 5, 13, 16, 17, 18, 19, 21, 23, 27, 31, 33 & 36)	1
1	6951061	Pin, treadle	2
2	6951058	Roller	1
3	6951056	Treadle	1
4	2031766	Pin, Cotter	2
5	6951057	Boot	1
6	6951060	Plunger	1
7	2056486	Screw, Machine	3
8	6951059	Flange, Mounting	1
9	2054812	Valve Assy., Basic (Incl. Items 10 thru 41)	1
10	6951027	Ring, Retaining	1
11	6951028	Retainer, Spring	1
12	6951029	Spring, Metering	1
13	6951031	"O" Ring	1
14	6951030	Piston	1
15	2031428	Screw	4
15A	2031389	Washer, Lock	4
16	6951034	Valve, Inlet	1
17	6951038	Tetraseal	1
18	6951041	Tetraseal	1
19	6951044	"O" Ring	1
20	6951054	Body	1
21	6951053	Valve, Inlet	1
22	6951051	Guide, Valve	1
23	6951049	"V" Packing	1
24	6951047	Shield, Exhaust	1
25	6951045	Ring, Retaining	1
26	6951048	Retainer, Seal	1
27	6951050	Tetraseal	1
28	6951052	Spring, Inlet Valve	1
29	6951046	Spring, Return	1
30	6951042	Piston	1
31	6951043	"O" Ring	1
32	6951039	Cover	1
33	6951040	"O" Ring	1
34	6951033	Rod, Push	1
35	6951036	Guide, Valve	1
36	6951037	"V" Packing	1
37	6951035	Spring, Inlet Valve	1
38	6951055	Body	1
39	6951032	Spring, Return	1
40	6951026	Piston Assy. (Incl. Items 10, 11, 12 & 14)	1
41	6951025	Retainer, Spring	1
42	6951062	Setscrew	1
43	2058864	Nut, Jam	1

The ends of the axles incorporate a planetary system which provides a 3.6:1 reduction of the rotational force from the differential, so that, in combination with the differential, the axle provides a total reduction of 26.64:1.

Rotational force from the differential is transferred to the planetary assemblies through an axle shaft. The spur teeth of the sun gear at the end of the axle shaft mesh with the teeth of planet spur gears. The planet spur gears mount on a spider and in turn mesh with the teeth of a floating internal tooth ring gear. The ring gear is rigidly mounted so that the planet spur gears "walk" around the ring gear and turn the planetary spider, which, in turn, causes rotation of hubs, on which the rims and tires are mounted. The brake drum is bolted to and rotates with the hub. Brake shoes are internally mounted within the drums.

AXLE PLANETARY DISASSEMBLY

Refer to the Axle Planetary Hub illustration for parts identification.

Jack up both ends of axle so that tires clear the ground. Due to the extreme weight of the vehicle, block up under each axle pad to support the weight safely and hold axle at this level. Remove jacks to provide adequate working space with no danger of axle ends falling or shifting

Remove the wheel nuts (17). Remove the wheel.

Rotate hub assembly so that the drain plug (15) is at the bottom. Remove the plug and drain lubricant.

Remove the bolts (40) and lockwashers that secure the planetary cover and thrust button assembly (38) to the planetary gear spider (33); remove the cover and gasket (37).

Remove the bolts (36) and lockwashers that secure the planetary gear spider (33) to the hub and cup assembly (16). Turn puller bolts into the threaded holes provided in the planetary spider flange to pull the spider from the hub.

Press the planetary pinion shafts (34) from the spider (33) and remove the planetary pinions (30) and thrust washers (29) and (31).

Remove the retaining ring (28) that secures the sun gear (27) to the axle shaft (9); remove the sun gear and thrust washer (26).

Pull straight out on the axle shaft (9) to remove it from the axle housing.

Remove the lock halves (25) that secure the bearing adjusting nut (24) on the spindle. Remove the bearing adjustment nut (24).

Support the weight of the assembled brake drum and hub with a hoist.

Use puller screws in the threaded holes in the flange of the ring gear hub (22) to pull the assembled planetary ring gear (23) and hub from the spindle.

Remove the lockwire, bolts (20), and four ring gear locks (21) that secure the ring gear to the hub; remove the ring gear. Use a puller to remove the outer bearing cone (19) from the ring gear hub.

Lift the hub and drum slightly to relieve hub weight and brake shoe drag. Pull the assembled hub and cup assembly (16) and drum (12) from the spindle and brake assembly. If hub or drum must be replaced, remove the lockwires and bolts (11) that secure the drum to the hub; remove the drum and oil slinger (13). Use a suitable puller to remove the bearing cups (1 and 18) from the hub.

Remove the bearing cone (2), retainer (3) and oil seal (4) from the spindle (6). To remove the brakes as an assembly, remove the bolts (10), nuts, and lockwashers that secure the brake assembly and spindle (6) to the axle housing. Remove its brakes and spindle.

Remove the "O" ring (7) and oil seal retainers (8) from the spindle (6).

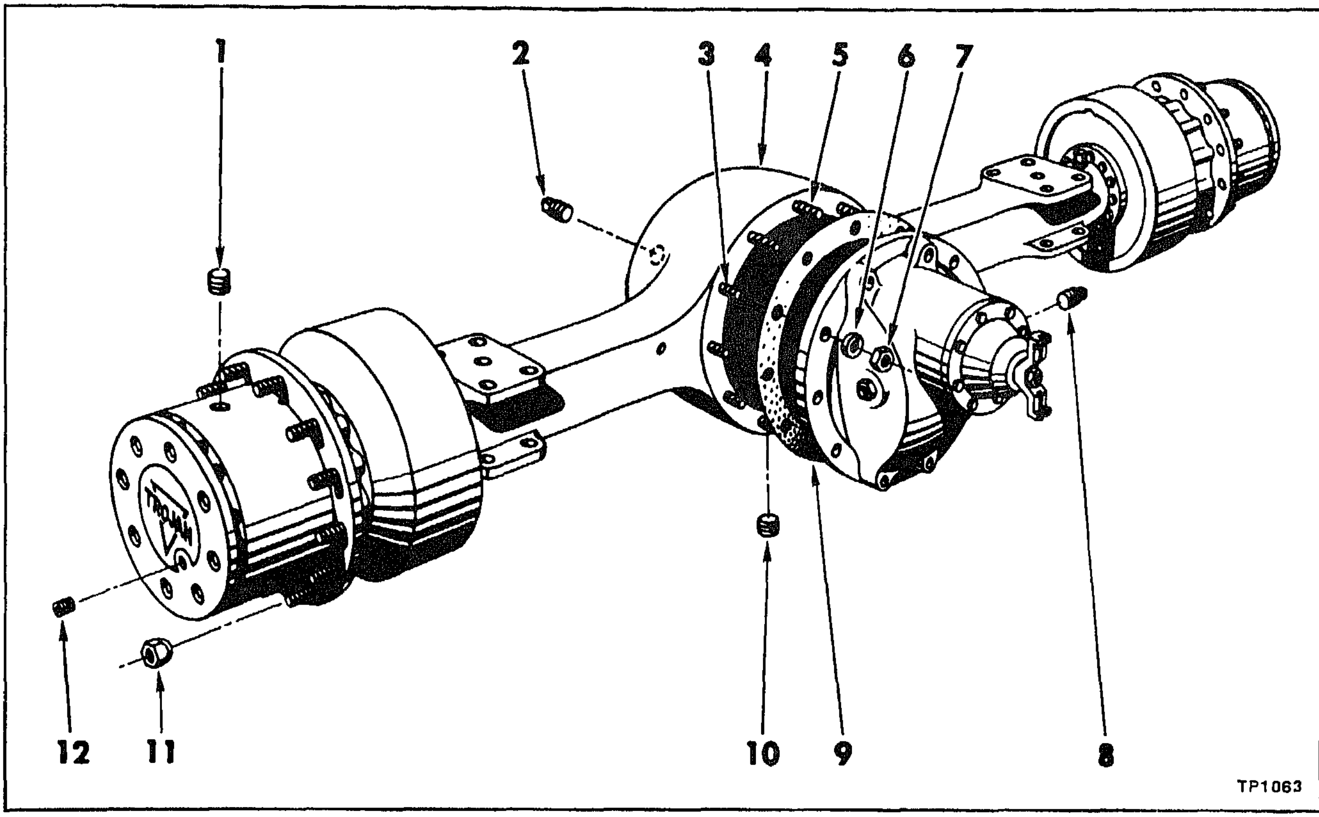
AXLE PLANETARY CLEANING AND INSPECTION

Clean parts with ground and polished surfaces, including gears, bearings, shafts, and collars, with a suitable solvent such as kerosene or diesel fuel.

CAUTION: Do not clean parts with gasoline. Do not use a hot solution tank or strongly alkaline water solutions containing sodium hydroxide, orthosilicates, or phosphates to clean ground and polished parts. Do not steam-clean parts after they have been removed from the axle housing. This will cause corrosion of close tolerance parts and also cause rust particles to become entrained in the lubricating oil.

Rough casting parts may be cleaned in hot solution tanks using mild alkali. Allow parts to remain in the tank long enough to be thoroughly cleaned and heated through. The heat will aid evaporation of the rinse water after washing. Rinse thoroughly to remove all traces of alkali.

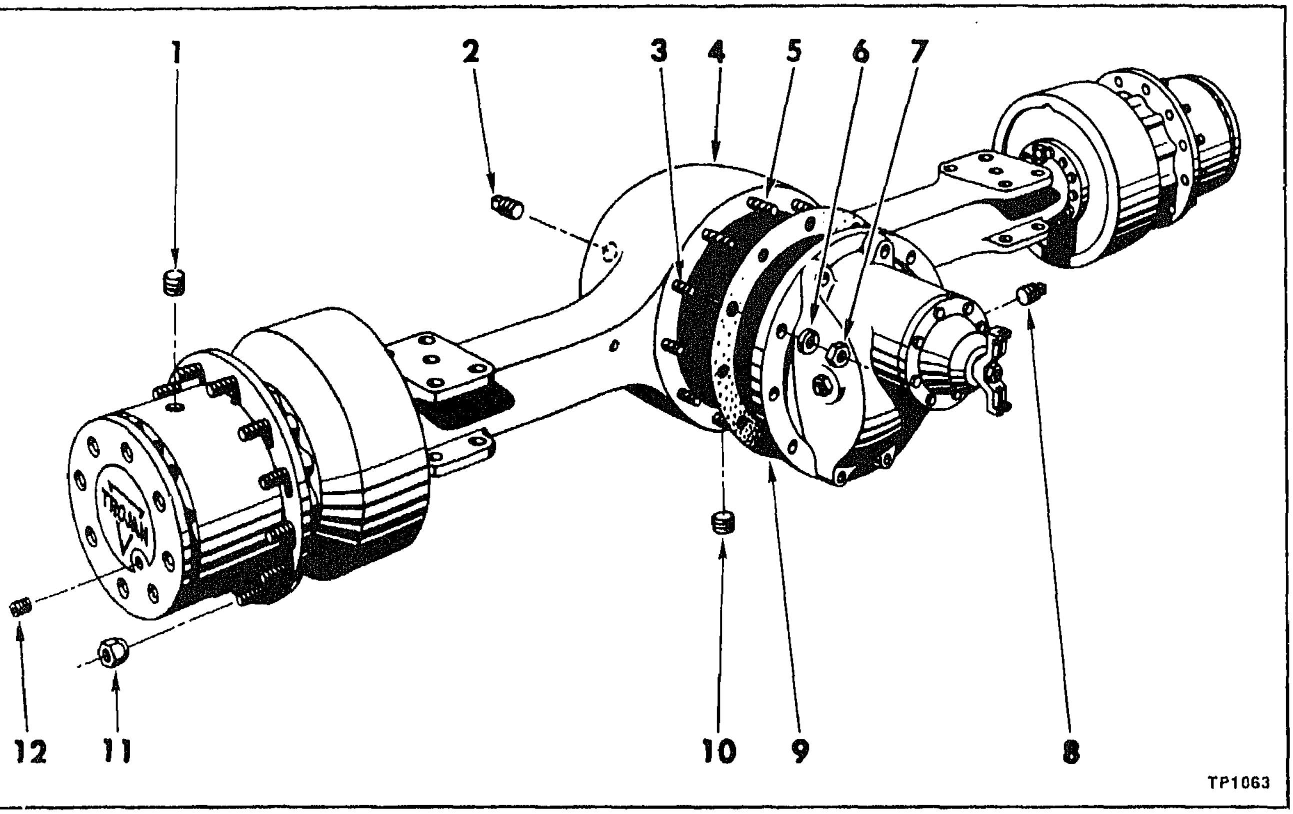
Dry all parts immediately after cleaning, using soft, lintless paper towels or wiping rags. Prevent lapping compound, metal filings, or contaminated oils from entering the parts. Coat all parts with light oil immediately after inspection to prevent corrosion. If parts are to be stored before reassembly, treat them with a good rust preventive and wrap them in protective paper. Carefully inspect all bearing cups and cones for wear, scoring, pitting, or other damage.



REAR AXLE ASSEMBLY

Item	Part No.	Description	No. Req'd.
A	2068107	Axle Assy., Rear	1
1	2006506	Planetary Dain & Fill Plug	2
2	2006298	Differential Level Plug	1
3	2016316	Stud, Carrier to Housing, Short	10
4	6600643	Axle Housing (Incl. Items 2, 3, 5 & 10)	1
5	6600648	Stud, Carrier to Housing, Long	4

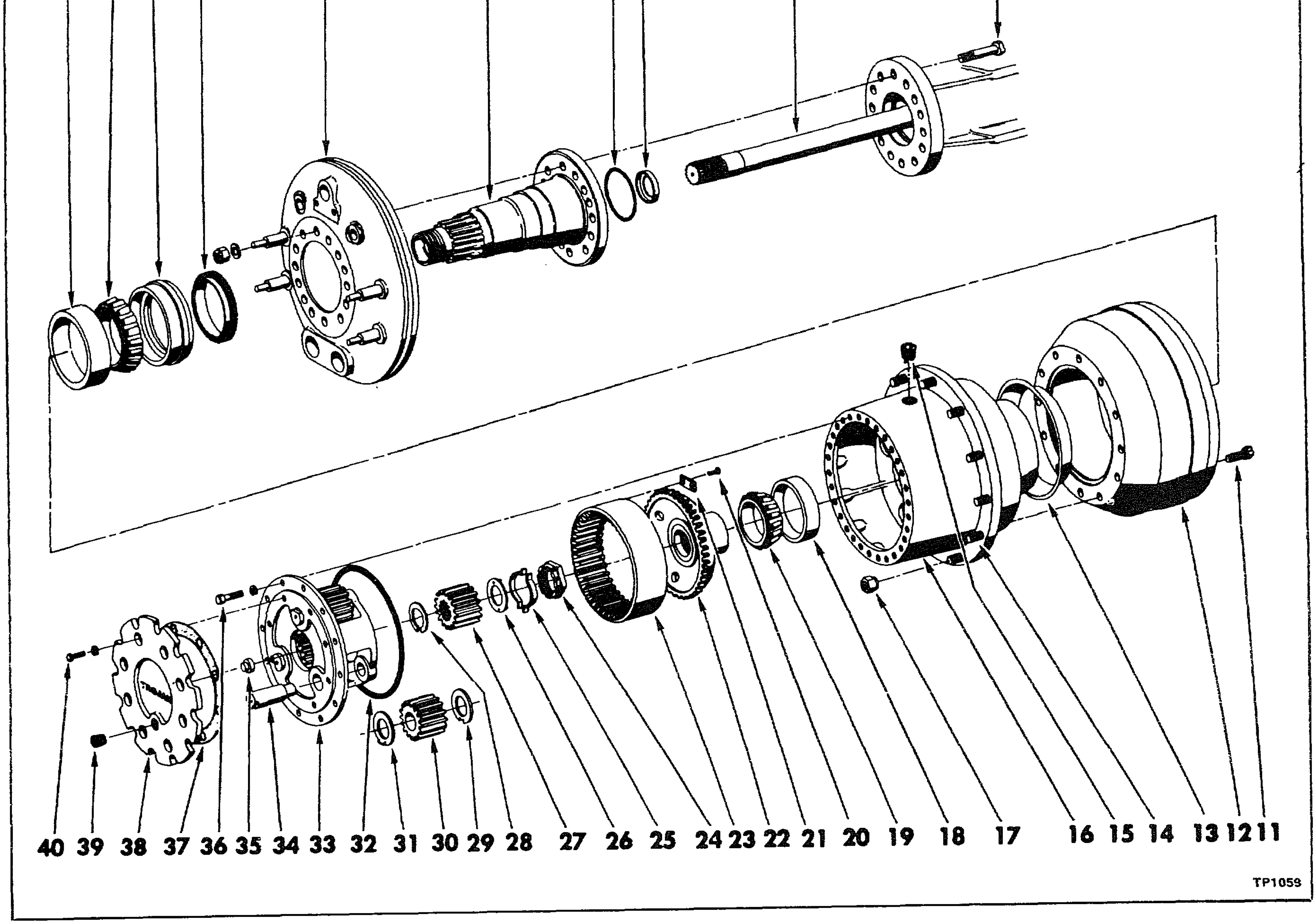
Item	Part No.	Description	No. Req'd.
6	6600644	Washer, Lock	14
7	6600645	Nut, Carrier to Housing	14
8	2033389	Plug, Differential, Fill	1
9	2016226	Gasket	1
10	6600651	Plug, Differential, Drain	1
11	2017694	Nut, Wheel	24
11A	2017688	Stud, Wheel	24
12	2034287	Plug, Planetary Level	2



FRONT AXLE ASSEMBLY

m	Part No.	Description	No. Req'd.
	2068106	Axle Assy., Front	1
	2006506	Plug, Planetary Drain	2
	2006298	Plug, Differential Level & Filler	1
	6600296	Stud, Carrier to Housing, Short	10
	6600649	Housing, Axle (Incl. Items 2, 3, 5 & 9)	1
	2006240	Stud, Carrier to Housing, Long	4

Item	Part No.	Description	No. Req'd.
9	2041783	Gasket	1
8	2006298	Plug, Differential Filler	1
7	6600344	Nut, Carrier to Housing	14
6	6600482	Washer, Lock	14
10	2034663	Plug, Differential Drain	1
11A	2042298	Stud, Wheel	24
11	2017694	Nut, Wheel	24
12	2034287	Plug, Planetary Level	2



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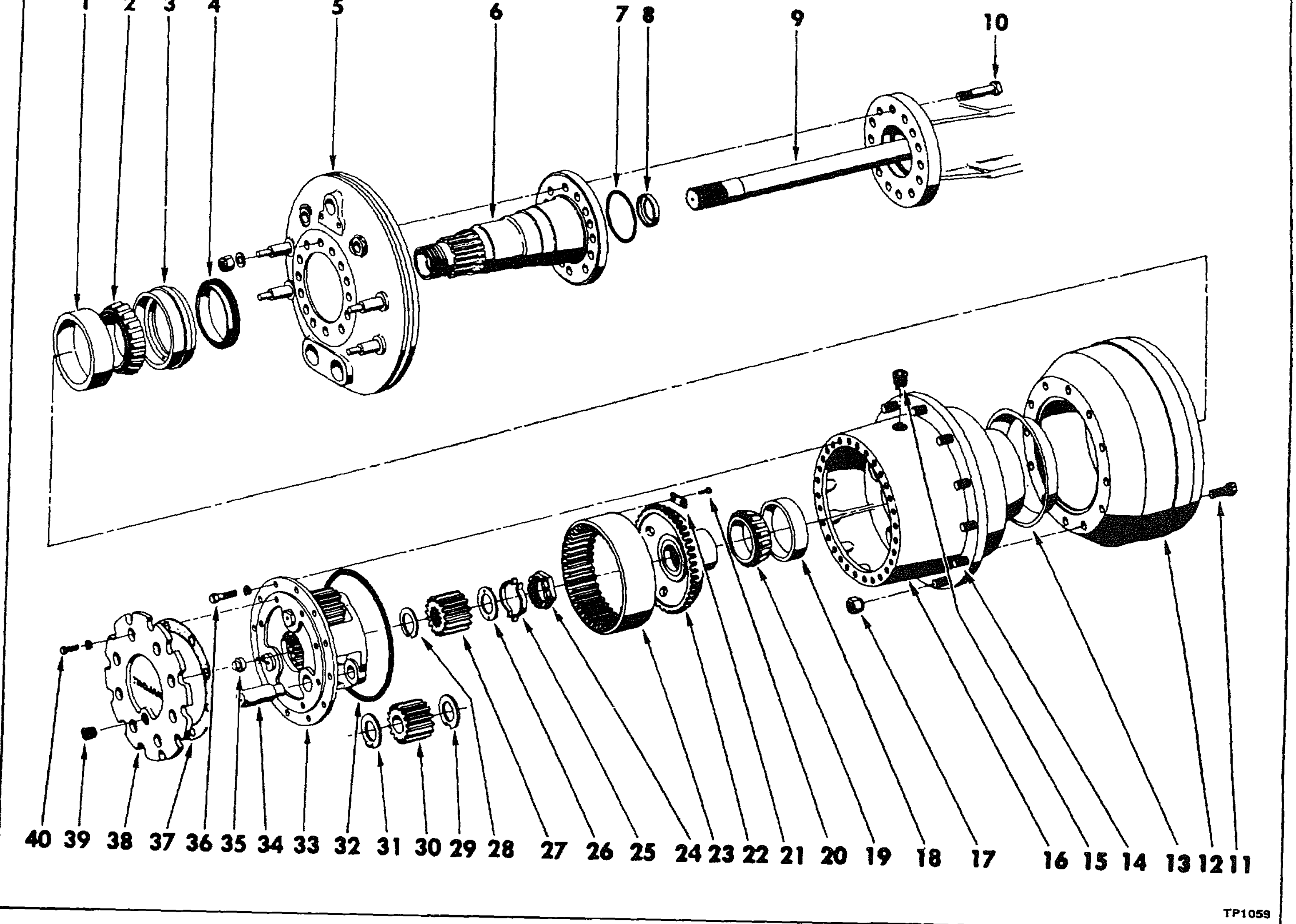
REAR AXLE PLANETARY HUB

Item	Part No.	Description	No. Req'd.
1	2035796	Cup, Inner Bearing	2
2	2035818	Cone, Inner Bearing	2
3	2035817	Retainer & Seal Assy. (Incl. Item 4)	2
4	2035816	Seal, Oil	2
5	2041416	Spider & Cam Assy., Brake	2
6	2035822	Spindle, Wheel Bearing	2
7	2034490	"O" Ring	2
8	———	(Not Applicable)	
9	6600647	Shaft	2
10	2032225	Bolt, Spindle to Housing	28
10A	2035813	Washer	28
10B	6600344	Nut	28
11	2032876	Bolt, Brake Drum to Hub	20
12	2035815	Brake Drum	2
13	2035821	Slinger, Oil	2
14	2017688	Stud, Wheel	24
15	2006506	Plug, Oil Drain	2
16	2035823	Hub & Cup Assy. (Incl. Items 1 & 19)	2
17	2017694	Nut, Wheel	24
18	2034716	Cup, Outer Bearing	2
19	2034715	Cone, Outer Bearing	2
20	2006452	Bolt, Ring Gear Lock	16
21	2034503	Lock, Planetary Ring Gear	8
22	2034785	Hub & Sleeve Assy., Ring Gear	2
23	2304771	Gear, Planetary Ring	2
24	2034742	Nut, Hub Bearing	2
25	2034513	Lock, Hub Bearing Nut	4
26	2034744	Washer, Sun Gear	2
27	2034772	Gear, Planetary Sun	2
28	2034751	Ring, Retaining	2
29	6600160	Washer, Thrust, Inner	6
30	2034773	Pinion, Planetary	6
31	2034506	Washer, Thrust, Outer	6
32	2042828	"O" Ring	2
33	2034787	Spider, Planetary Gear	2
34	6600161	Shaft, Planetary Pinion	6
35	2017646	Button, Thrust	2
36	2034483	Bolt, Planetary Spider to Hub	32
36A	2031393	Washer, Lock	32
37	2034514	Gasket	2
38	2034519	Cover & Thrust Button Assy. (Incl. Item 36)	2
39	2034287	Plug, Oil Filler	2
40	6600646	Bolt, Planetary Spider Cover	16
40A	2031392	Washer, Lock	16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FRONT AXLE PLANETARY HUB

Item	Part No.	Description	No. Req'd.
1	2034489	Cup, Outer Bearing	2
2	2034488	Cone, Outer Bearing	2
3	6600706	Retainer & Seal Assy. (Incl. Item 4)	2
4	6600705	Seal, Oil	2
5	2041753	Spider & Cam Assy., Brake	2
6	2034526	Spindle, Wheel Bearing	2
7	2034490	"O" Ring	2
8	———	(Not Applicable)	
9	6600650	Shaft	2
10	2034484	Bolt, Spindle to Housing	28
10A	2034452	Washer	28
10B	2041786	Nut	28
11	2032876	Bolt, Brake Drum to Hub	24
12	2034517	Brake Drum	2
13	2034528	Slinger, Oil	2
14	2042298	Stud, Wheel	24
15	2006506	Plug, Oil Drain	2
16	6600036	Hub & Cup Assy. (Incl. Items 1 & 19)	2
17	2017694	Nut, Wheel	24
18	2034489	Cup, Inner Bearing	2
19	2034488	Cone, Inner Bearing	2
20	2006452	Bolt, Ring Gear Lock	16
21	2034503	Lock, Planetary Ring Gear	8
22	2034524	Hub & Sleeve Assy., Ring Gear	2
23	2034523	Gear, Planetary Ring	2
24	2034742	Nut, Hub Bearing	2
25	2034513	Lock, Hub Bearing Nut	4
26	2034508	Washer, Sun Gear	2
27	2034522	Gear, Planetary Sun	2
28	2034510	Ring, Retaining	2
29	6600160	Washer, Thrust, Inner	6
30	2034521	Pinion, Planetary	6
31	2034506	Washer, Thrust, Outer	6
32	2042828	"O" Ring	2
33	6600038	Spider, Planetary Gear	2
34	6600162	Shaft, Planetary Pinion	6
35	2017646	Button, Thrust	2
36	2034483	Bolt, Planetary Spider to Hub	60
36A	2031393	Washer, Lock	60
37	2034514	Gasket	2
38	2034518	Cover & Thrust Button Assy. (Incl. Item 36)	2
39	2034287	Plug, Oil Filler	2
40	6600646	Bolt, Planetary Spider Cover	16
40A	2031392	Washer, Lock	16

nspect planet gears, sun gears, and ring gears for vear and damage. Replace gears that are scored, pitted, idged, galled, or worn.

nspect drive shafts for signs of torsional fractures or ther signs of impending failure.

Replace lockwasher, snap rings, oil seals, gaskets, and imilar expendable parts at each overhaul.

Remove nicks, mars, and burrs from machined or ground surfaces with a fine mill file or India stone. Make sure all threaded parts are clean in order that all parts may be properly adjusted and torqued. Remove ll burrs caused by lockwashers to assure easy reassembly of parts.

AXLE PLANETARY REASSEMBLY

nstall a new oil seal retainer (8) in the inner end of the spindle (6), using a suitable driver. Position a new "O" ring on the inner lip of the spindle nd position the spindle assembly and brake assembly n the axle housing; secure with bolts (10) and nuts. Torque nuts to 185 to 205 lb. ft. on the rear axle and 320 to 415 lb. ft. on the front axle.

f they were removed, install new bearing cups (1 and 18) in the hub (16). Position the oil slinger (13) and brake drum (12) on the hub and secure with bolts (11) nd torque to 160 to 205 lb. ft. Lockwire bolts in pairs. nstall the bearing cone (2), oil seal retainer (3) and il seal (4) in hub.

Use a hoist to position the assembled hub and drum n the spindle, taking care not to damage the seal. Continue to support the hub and drum.

Press the bearing cone (19) on the ring gear hub (22). Position the ring gear (23) on the hub; secure with four ring gear locks (21), each of which is held in place with wo bolts (20). Torque bolts to 33 to 43 lb. ft.

Position the assembled ring gear and hub on the spindle. If necessary, raise or lower the brake drum and hub as necessary to allow the bearing cone (19) to seat n the bearing cup (18). Install the wheel bearing adjustment nut (24). Tighten the adjustment nut against he ring gear hub to 400 lb. ft. torque while rotating he wheel in both directions. Make sure all parts are ully seated. Back off the adjusting nut one-quarter urn to relieve preload on the bearings.

f Wheel Bearings are New, check the rotating torque with a pull scale and cord. Wrap the cord around the hub and hook the spring scale on the end of the cord. (Refer to Fig. 107). Check the pull necessary to cause he wheel to continue (not start) rotation. Force required to keep wheel rotating must be between 11 and 17 pounds (6 to 10 lb. ft. torque on the front axle and to 9 lb. ft. torque on the rear axle.) Advance the wheel nut in small increments until the proper bearing preload is attained. Install the adjusting nut lock (25).

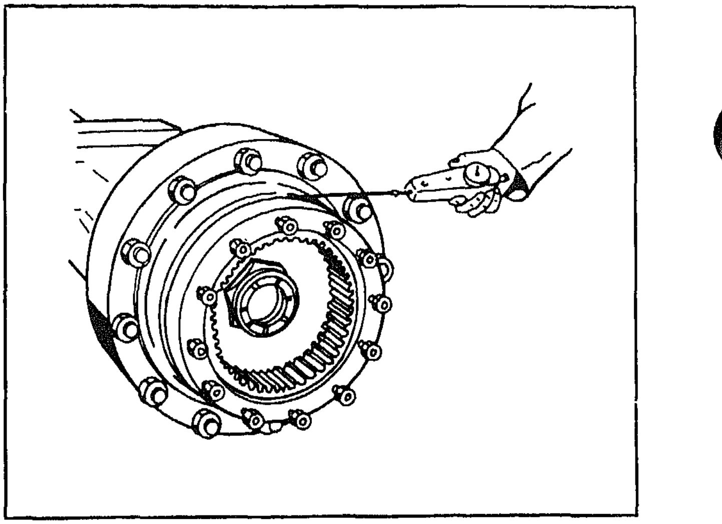


Fig. 107 Checking Wheel Bearing Preload

If USED Wheel Bearings are installed, be certain they are installed in the original manner. Advance the adjusting nut in small increments until an increase in rotating torque is noted. If the increase is slight, install the nut lock (25). If necessary, back off the nut slightly to permit nut lock installation. If the preload increase is appreciable, back off the nut until only a slight increase in preload is noted. Install the nut lock.

Install the axle shaft (9) so that it engages the splines of the differential. Position the thrust washer (26) on the axle shaft so that the pins in the washer engage the recesses in the adjustment nut (24). Install the sun gear (27) nd secure it to the axle shaft with a retaining ring (28).

With the planetary gear spider (33) flat on a bench, install the inner thrust washer (29) so that the tang on the washer engages the recess in the spider. Install the planetary pinion (30) and outer thrust washer (31). Secure by installing the planetary pinion shaft (34) with the small diameter first and the flat on the opposite end toward the outside of the hub circle. Press the shaft in place until it rests against the inner thrust washer. Install the remaining two planetary gears in the same manner.

Install a new "O" ring (32) on the planetary spider assembly and position the planetary spider on the axle so that the planetary gears engage the teeth of the sun gear and the ring gear. Secure the planetary spider to the hub with bolts (36) and lockwashers. Torque bolts to 82 to 91 lb. ft.

Be certain thrust button (35) is firmly seated in planetary spider cover (38). Position planetary spider cover and gasket (37) on the hub and secure with bolts (40) and lockwashers. Torque bolts to 59 lb. ft.

Install tire and rim. Consult Wheel Mounting Instructions. (See Index.)

Lubricate planetary assembly as directed in the lubrication chart.

AXLE BRAKE OVERHAUL

Hydraulic brakes are used to slow or stop the vehicle. The hydraulic pressure is supplied by an air-over-hydraulic system through a power cluster. When the brakes are actuated, hydraulic pressure is applied to the wheel cylinder mounted between the brake shoes. This causes the pistons mounted in the wheel cylinder to move apart, moving the brake shoes. The linings of the brake shoes are pressed against the inside of the brake drum, causing friction to be created between the stationary brake linings and the rotating drums. The friction causes the brake drums—and the vehicle—to slow down or stop.

AXLE BRAKE DISASSEMBLY

Refer to the Front or Rear Axle Brake illustration for parts identification. Remove the axle planetary as directed in the Axle Planetary Overhaul Section to expose the brake drums and operating parts. Brake shoes or brake springs can be replaced without removing the entire brake assembly from the axle.

FRONT AXLE BRAKE

Remove the brake shoe return springs (26). Remove the guide pin "C" washers (31) and washers (30). Remove the anchor pin "C" washers (28) and remove the anchor pin link (27). Remove the assembled brake shoes (29) and linings (32).

Remove the screws (16) that secure the wheel cylinder assembly (6) to the brake cam and spider assembly (18); remove the wheel cylinder assembly.

Remove the yoke assemblies (1), boots (2), pistons (3), cups (4), and spring and retainer assembly (5) from the wheel cylinder. Remove the inlet fitting bolt (12), gasket (11), and inlet fitting (10) from the wheel cylinder. Remove the bleeder screw (8) from the wheel cylinder.

Do not remove the brake shoe adjusting cams (23) and springs (22) from the brake spider and cam assembly unless they are damaged and require replacement. If anchor pins (20) are worn or damaged, remove the retaining rings (17) and drive out the anchor pins.

REAR AXLE BRAKE

Remove the brake shoe return springs (23). Remove the guide pin "C" washers (29) and washers (28). Remove the anchor pin "C" washers (26) and remove the anchor pin link (25). Remove the assembled brake shoes (24) and linings (30).

Remove the screws (13) that secure the wheel cylinder assembly (6) to the brake cam and spider assembly (17); remove the wheel cylinder assembly.

Remove the yoke assemblies (1), boots (2), pistons (3), cups (4), and spring and retainer assembly (5) fror the wheel cylinder. Remove the inlet fitting bolt (10) gasket (9), and inlet fitting (8) from the wheel cylin der. Remove the bleeder screw (7) from the whee cylinder.

Do not remove tthe brake shoe adjusting cams (21 and springs (19) from the brake spider and cam assem bly unless they are damaged and require replacemen If anchor pins (18) are worn or damaged, remove th retaining rings (14) and drive out the anchor pins.

AXLE BRAKE CLEANING, INSPECTION AND REPAIR

Wire brush the brake shoes to remove all dirt, rus or scale. Clean all metallic parts with a suitable solven such as kerosene or diesel fuel. Do not attempt to clea brake shoes and linings with cleaning solvent. Replac rubber parts of the brake wheel cylinder.

Inspect the brake drums for wear, scoring and othe damage. If the inner wear surfaces of the brake drum are damaged, turn them down on a lathe, machinin them in increments of 1/16-inch increase on the radius If brake linings are worn so that the rivet heads ar close to the friction surface of the lining, the brak lining must be replaced. Drill out the crimped end o the rivets and drive the rivets with a punch. Thoroughl clean the contact faces of the linings and shoes an clamp the linings in position on the shoes using "C clamps, so that the holes in the shoes and linings ar aligned. Drive in rivets with a 7/16-inch flat head drif Make sure the "C" clamp is located as close as possibl to the rivet hole. Form the rivet heads with the correc tubular rivet set following the sequence given in Fig. 108

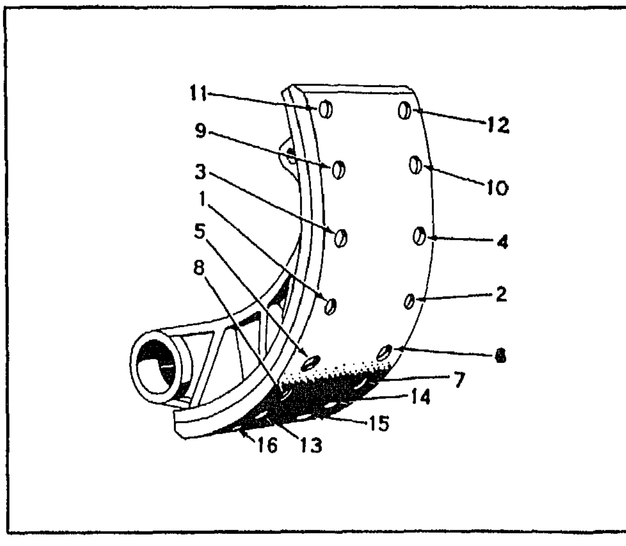
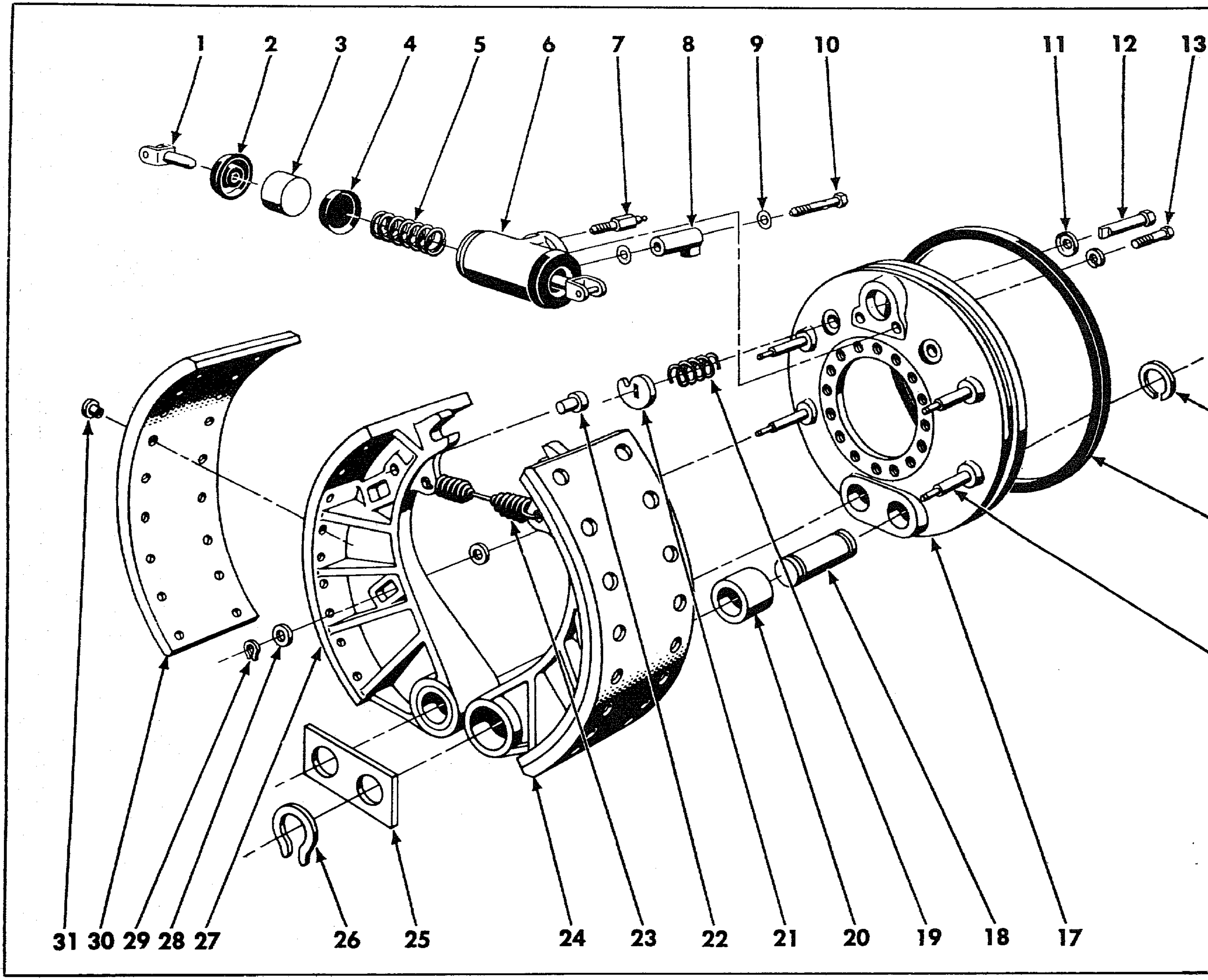


Fig. 108. Brake Shoe Riveting Sequence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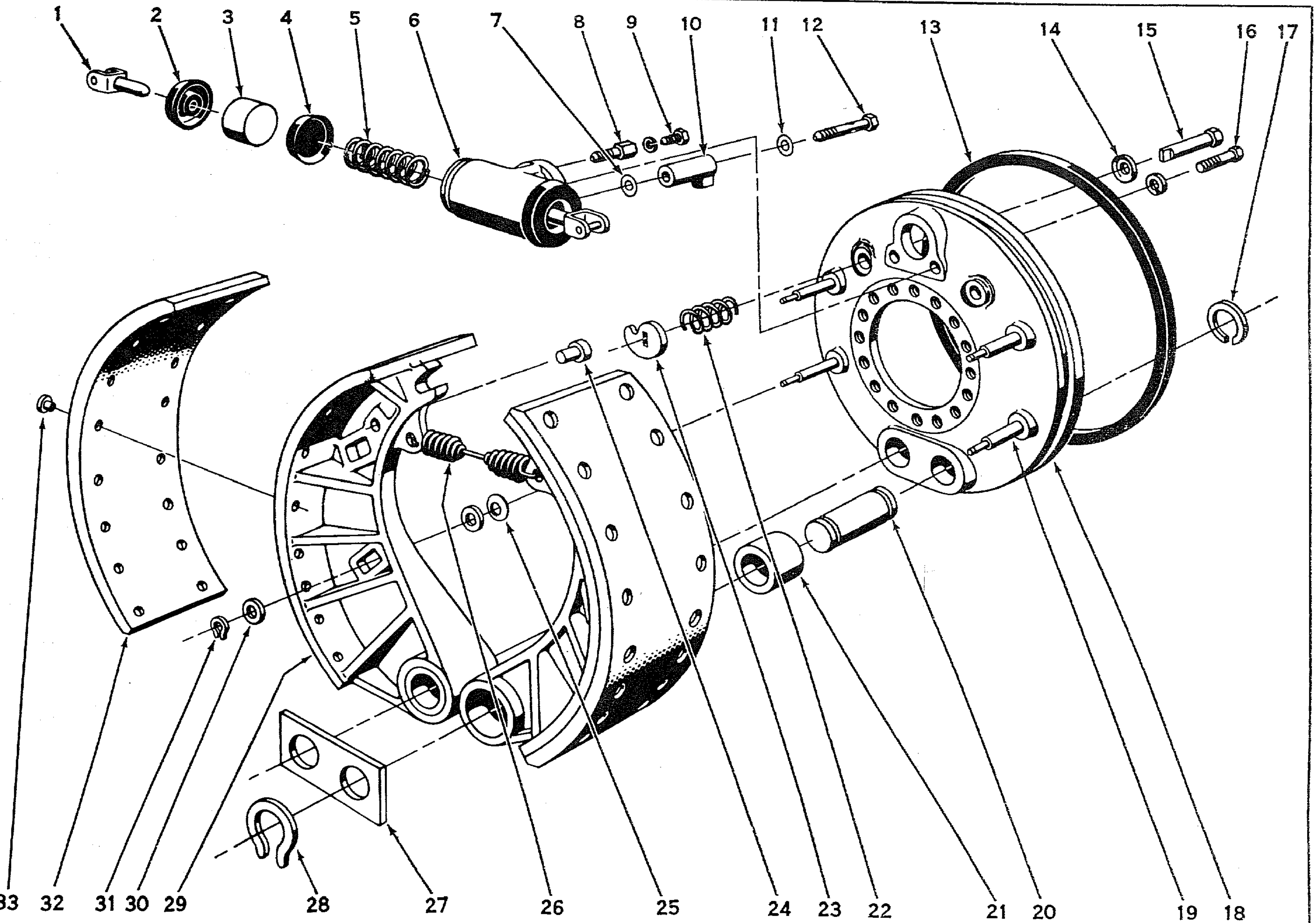
REAR AXLE BRAKE GROUP

Item	Part No.	Description	No. Req'd.
1	2034839	Yoke Assy.	4
2	2034562	Boot	4
3	2034559	Piston	4
4	2042010	Cup	4
5	2034561	Spring & Retainer Assy.	2
6	6600061	Wheel Cylinder Assy. (Incl. Items 1 thru 10)	2
7	2042011	Screw, Bleeder	2
8	2033379	Connection, Inlet	2
9	2012046	Gasket, Outside	2
9A	2033395	Gasket, Inside	2
10	2033394	Bolt	2
11	2034536	Washer, Brake Shoe Adjusting Cam Pin	4
12	2034534	Pin, Brake Shoe Adjusting Cam (Incl. Item 11)	4
13	2037614	Capscrew, Cylinder to Spider	4
13A	2031391	Washer, Lock, Cylinder to Spider	4
14	2022464	Ring, Snap, Brake Shoe Anchor Pin	4
15	2034539	Seal, Brake Drum	2
16	2034532	Pin, Brake Shoe Guide	8
16A	2006378	Washer, Brake Shoe Guide Pin	16

Item	Part No.	Description	N
17	2041416	Spider, Brake (Incl. Items 11, 12, 14, 15, 16, 18, 19 & 21)	
18	2035743	Pin, Anchor, Brake Shoe	
19	2034537	Spring, Brake Adjusting Cam	
20	6600400	Bushing, Brake Shoe	
21	2034538	Adjusting Cam, Brake Shoe	
22	2035745	Pin, Stop	
23	2034550	Spring, Brake Shoe Return	
24	2034544	Brake Shoe Assy. (Incl. Items 20, 22, 27, 30, 31)	
25	2041417	Link, Brake Shoe Anchor Pin	
26	2018354	"C" Washer, Brake Shoe Anchor Pin	
27	———	Brake Shoe (N.S.S.) (Order Item 24)	
28	2041175	Washer, Spring, Brake Shoe Guide Pin	
29	2034541	"C" Washer, Brake Shoe Guide Pin	
30	2034546	Lining, Brake Shoe	
31	2034547	Rivet, Brake Shoe Lining	
32	6600438	Capscrew (N.I.)	
32A	2031389	Washer, Lock (N.I.)	

(N.I.) Not Illustrated)

(N.S.S.) Not Serviced Separately.



FRONT AXLE BRAKE GROUP

TP779

FRONT AXLE BRAKE GROUP

Item	Part No.	Description	No. Req'd.
1	2034839	Yoke Assy.	4
2	2034562	Boot	4
3	2034559	Piston	4
4	2042010	Cup	4
5	2034561	Spring & Retainer Assy.	2
6	6600061	Cylinder Assy., Wheel (Incl. Items 2 thru 5)	2
7	2033395	Gasket	2
8	2042011	Screw, Bleeder	2
9	6600438	Screw	2
9A	2031389	Washer, Lock	2
10	2033379	Fitting, Inlet	2
11	2012046	Gasket	2
12	2033394	Bolt, Inlet Fitting	2
13	2034539	Seal, Brake Drum	2
14	2034536	Washer	4
15	2034534	Pin & Washer Assy., Shoe Adjusting (Incl. Item 14)	4
16	2037614	Screw, Cylinder to Spider	4
16A	2031391	Washer, Lock	4
17	2022464	Ring, Retaining	4
18	2041753	Spider & Cam Assy., Brake (Incl. Items 13, 17, 19, 20, 22 & 23)	
19	2034532	Pin, Brake Shoe Guide	
20	2035743	Pin, Brake Anchor	
21	2035744	Bushing	
22	2034537	Spring, Shoe Adjusting Cam	
23	2034538	Cam, Brake Shoe Adjusting	
24	2035745	Pin, Stop	
25	2041175	Washer, Spring, Guide Pin	
26	2034550	Spring, Brake Shoe Return	
27	2041417	Link, Anchor Pin	
28	2018354	"C" Washer, Anchor Pin	
29	2034544	Shoe Assy., Brake (Incl. Items 21, 24, 32 & 33)	
30	2034533	Washer, Guide Pin	
31	2034541	"C" Washer, Guide Pin	
32	2034546	Lining Assy. (Incl. Item 33)	
33	2034547	Rivet	

linings are painted yellow on the edge. Since the wheel cylinder is directly above the axle, the front shoe must be the primary shoe, the rear shoe the secondary shoe.

Inspect the wheel cylinder pistons for wear and scoring.

Inspect the bore of the wheel cylinder for wear and scoring. Install new boots and cups in the wheel cylinder at every overhaul.

Inspect brake shoe bushings (21), front axle and brake shoe bushings (20), rear axle for wear or scoring. If necessary, press out bushings and install new bushings.

AXLE BRAKE REASSEMBLY

Refer to the Front or Rear Axle Brake illustration for parts identification.

FRONT AXLE BRAKE

Install the spring and retainer assembly (5), cups (4), pistons (3), boots (2) and yoke assemblies (1) on the wheel cylinder (6). Install the inlet fitting (10) with a bolt (12) and gasket (11). Install the bleeder screw (8). If anchor pins were removed, drive the pins (20) into the brake spider and cam assembly and install the retainer ring (17).

Position the assembled wheel cylinder on the spider and cam assembly; secure with two screws (16).

Position the guide pin spring washers (25) and guide pin washers on the guide pins (19). Position the brake shoe assemblies (29) on the anchor pins and guide pins. Secure the guide pins with one guide pin washer (30) and guide pin "C" washer at each guide pin. Install the anchor pin link (27) and two anchor pin "C" washers (28).

Use brake spring pliers to install the brake shoe return spring (26) between the brake shoes.

REAR AXLE BRAKE

Install the spring and retainer assembly (5), cups (4), pistons (3), boots (2), and yoke assemblies (1) on the wheel cylinder (6). Install the inlet fitting (8) with a bolt (10) and gasket (9). Install the bleeder screw (7). If anchor pins were removed, drive the pins (18) into the brake spider and cam assembly and install the retainer ring (14).

Position the assembled wheel cylinder on the spider and cam assembly; secure with two screws (13).

Position the guide pin spring washers (28) on the guide pins (16). Position the brake shoe assemblies (24) on the anchor pins and guide pins. Secure the guide pins with one spring washer (28) and guide pin "C" washer (29) at each guide pin. Install the anchor pin link (25) and two anchor pin "C" washers (26).

Use brake spring pliers to install the brake shoe return spring (23) between the brake shoes.

DIFFERENTIAL OVERHAUL

The differential receives rotational force from the transmission through the propeller shafts, reduces the rotat-

DIFFERENTIAL REMOVAL AND DISASSEMBLY

Refer to the differential group illustration for parts identification.

The axle shafts that drive the planetaries engage splines in the differential side gears; these axle shafts must be removed before the differential and carrier can be removed. Refer to the disassembly instructions in the Axle Planetary Overhaul Section to remove the axle shafts from axle. Remove the drain plug from the axle housing to drain the differential bowl. Disconnect the propeller shafts from the companion yoke and slinger (23) of the differential.

Remove all but the top two nuts and washers that secure the differential and carrier to the axle housing. Loosen the top two, but leave them on the studs to prevent the differential and carrier from falling. Use a rawhide mallet to break the carrier loose from the axle housing. Remove the top two nuts and washers, and install puller screws in the threaded holes in the carrier flange. Use a small pinchbar if necessary to straighten the carrier in the housing bore, but take care not to damage the carrier flange. Use a roller jack to aid in removing the differential and carrier assembly from the vehicle.

Mount the differential in a differential stand. If initial inspection indicates replacement of the drive gear and pinion, check and record the drive gear backlash for use at reassembly.

Loosen the locknut (8) and back off the adjusting screw (7) on the front axle. Use a center punch to match mark the carrier bearing caps (43 and 46) to the differential carrier so that they can be properly reassembled. Cut the lockwire and remove the bolts (45) and washers (44) that secure the bearing caps to the carrier; remove the bearing caps and adjusting rings (1 and 37). Insert a bar through the differential to facilitate handling and lift out the assembled differential and drive gear assembly. Remove the adjusting screw (7) and thrust block (6) from the front axle carrier.

Match-mark the differential case plain half (41) to the differential case flange half (5) using a center punch. Cut lockwires and remove the bolts (47); and nuts (40), and washers from the front axle| that secure the case halves together. Separate the case halves and remove the thrust washers (35), side gears (34), and spider assembly from the case halves. Disassemble the thrust washers (30) and gears (32) from the spider (33). If necessary to replace differential bearing cones (3 and 36), press them from the case halves.

Hold the companion yoke and slinger assembly (23) with a suitable tool to prevent its rotation. Remove the cotter pin (22), and remove the nut (21) and washer (20) that secure the companion yoke to the drive pinion. Use a puller to remove the yoke from the pinion. Do not attempt to drive the yoke from the pinion as this may cause misalignment.

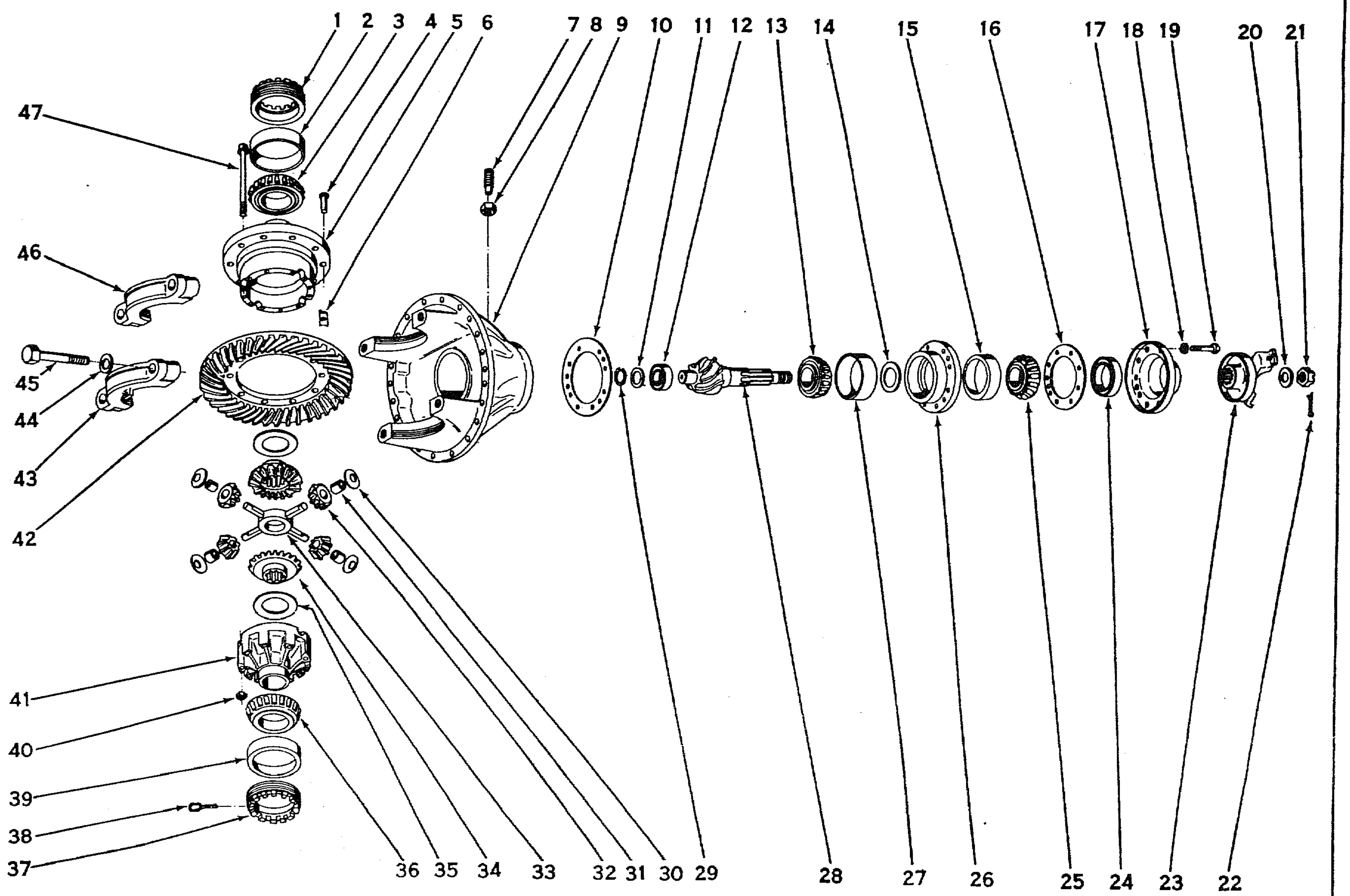

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FIGURE TP900

Item	Part No.	Description	No. Req'd.
A	6600348	Differential Carrier Assy., Complete (Front Axle)	1
B	6600340	Differential Carrier & Cap Assy. (Incl. Items 9 & 43 thru 46)	1
C	6600364	Differential Case Assy. (Incl. Items 5, 40, 40A, 41, 47 & 47A)	1
D	6600074	Drive Gear & Pinion Assy. (Incl. Items 28 & 42)	1
E	2042132	Pinion Forward Bearing Cage Assy. (Incl. Items 13, 14, 15, 25, 26 & 27)	1
1	2006278	Ring, Adjusting	1
2	2006290	Cup, Bearing	1
3	2006292	Cone, Bearing	1
4	2006232	Rivet	12
5	———	Flange Half, Differential Case (N.S.S.) (Order Item C)	1
6	———	Block, Thrust (Not Applicable)	
7	6600652	Screw, Adjusting	1
8	2006228	Locknut	1
9	———	Carrier, Differential (N.S.S.) (Order Item B)	1
10	2006310	Shim, Thin	AR
10	2034461	Shim, Medium	AR
10	2034463	Shim, .003	AR
11	2006234	Ring, Retaining	1
12	2006294	Bearing, Rear	1
13	———	Cone, Bearing (N.S.S.) (Order Item E)	1
14	———	Spacer (N.S.S.) (Order Item E)	1
15	———	Cup, Bearing (N.S.S.) (Order Item E)	1
16	2006312	Gasket	1
17	2034427	Cover & Oil Seal Assy.	1
18	2031393	Washer, Lock	8
19	2034483	Bolt	8
20	2006220	Washer	1
21	2006208	Nut	1
22	2006212	Pin, Cotter	1
23	2038389	Companion Yoke & Front Slinger Assy. (Rigid Axle)	1
24	2006216	Seal, Oil	1
25	———	Cone, Bearing (N.S.S.) (Order Item E)	1
26	———	Cage (N.S.S.) (Order Item E)	1
27	———	Cup, Bearing (N.S.S.) (Order Item E)	1
28	———	Pinion, Drive (N.S.S.) (Order Item D)	1
29	2006297	Ring, Lock	1
30	6600299	Washer, Thrust	4
31	———	Bushing (N.S.S.) (Order Item 32)	4
32	6600341	Gear	4
33	6600298	Spider	1
34	2034401	Gear, Side	2
35	2006262	Washer, Thrust	2
36	2006292	Cone, Bearing	1
37	2006278	Ring, Adjusting	1
38	6600704	Pin, Cotter	2
39	2006290	Cup, Bearing	1
40	6600033	Nut (Incl. in Item C)	12
40A	6600032	Washer (Incl. in Item C)	12
41	———	Plain Half, Differential Case (N.S.S.) (Order Item C)	1
42	———	Gear, Drive (N.S.S.) (Order Item D)	1
43	———	Cap, Bearing (N.S.S.) (Order Item B)	1
44	6600432	Washer (Incl. in Item B)	4
45	2034576	Bolt (Incl. in Item B)	4
46	———	Cap, Bearing (N.S.S.) (Order Item B)	1
47	6600366	Bolt, Long (Incl. in Item C)	8
47A	6600365	Bolt, Short (Incl. in Item C)	4

(N.S.S.) Not Serviced Separately

AR As Required

REAR AXLE DIFFERENTIAL GROUP

FIGURE TP900

Item	Part No.	Description	No. Req'd.
A	6600401	Differential Carrier Assy., Complete (Rear Axle)	1
B	6600402	Differential Carrier & Cap Assy. (Incl. Items 9, 43 thru 46)	1
C	6600418	Differential Case Assy. (Incl. Items 5, 41, 47 & 47A)	1
D	6600416	Drive Gear & Pinion Assy. (Incl. Items 28 & 42)	1
E	6600403	Pinion Forward Bearing Cage Assy. (Incl. Items 13, 14, 15, 25, 26 & 27)	1
1	6600427	Ring, Adjusting	1
2	6600436	Cup, Bearing (L.H.)	1
3	6600426	Cone, Bearing (L.H.)	1
4	6600437	Rivet	12
5	———	Flange Half, Differential Case (N.S.S.) (Order Item C)	1
6	———	Block Thrust (Not Applicable)	
7	———	Screw, Adjusting (Not Applicable)	
8	———	Nut, Lock (Not Applicable)	
9	———	Carrier, Differential (N.S.S.) (Order Item B)	1
10	2016714	Shim, Thin	AR
10	2016712	Shim, Medium	AR
10	2016710	Shim, .003	AR
11	2034639	Ring, Retaining	1
12	6600409	Bearing, Rear	1
13	———	Cone, Bearing (N.S.S.) (Order Item E)	1
14	———	Spacer (N.S.S.) (Order Item E)	1
15	———	Cup, Bearing (N.S.S.) (Order Item E)	1
16	2016642	Gasket	1
17	6600413	Cover & Oil Seal Assy.	1
18	———	Washer, Lock (Not Applicable)	
19	6600430	Bolt	
20	2034616	Washer	
21	6600475	Nut	
22	6600090	Pin, Cotter	
23	6600414	Companion Yoke & Slinger Assy.	
24	2006216	Seal, Oil	
25	———	Cone, Bearing (N.S.S.) (Order Item E)	
26	———	Cage (N.S.S.) (Order Item E)	
27	———	Cup, Bearing (N.S.S.) (Order Item E)	
28	———	Pinion, Drive (N.S.S.) (Order Item D)	
29	2034640	Ring, Lock	
30	6600428	Washer, Thrust	
31	———	Bushing (N.S.S.) (Order Item 32)	
32	6600419	Gear	
33	6600421	Spider	
34	6600420	Gear, Side	
35	6600429	Washer, Thrust	
36	6600425	Cone, Bearing (R.H.)	
37	6600427	Ring, Adjusting	
38	6600704	Pin, Cotter	
39	6600435	Cup, Bearing (R.H.)	
40	———	Nut (Not Applicable)	
40A	———	Washer (Not Applicable)	
41	———	Plain Half, Differential Case (N.S.S.) (Order Item C)	
42	———	Gear, Drive (N.S.S.) (Order Item D)	
43	———	Cap, Bearing (N.S.S.) (Order Item B)	
44	6600059	Washer	
45	2016864	Bolt (Incl. in Item B)	
46	———	Cap, Bearing (N.S.S.) (Order Item B)	
47	6600439	Bolt, Long (Incl. in Item C)	
47A	6600440	Bolt, Short (Incl. in Item C)	

(N.S.S.) Not Serviced Separately

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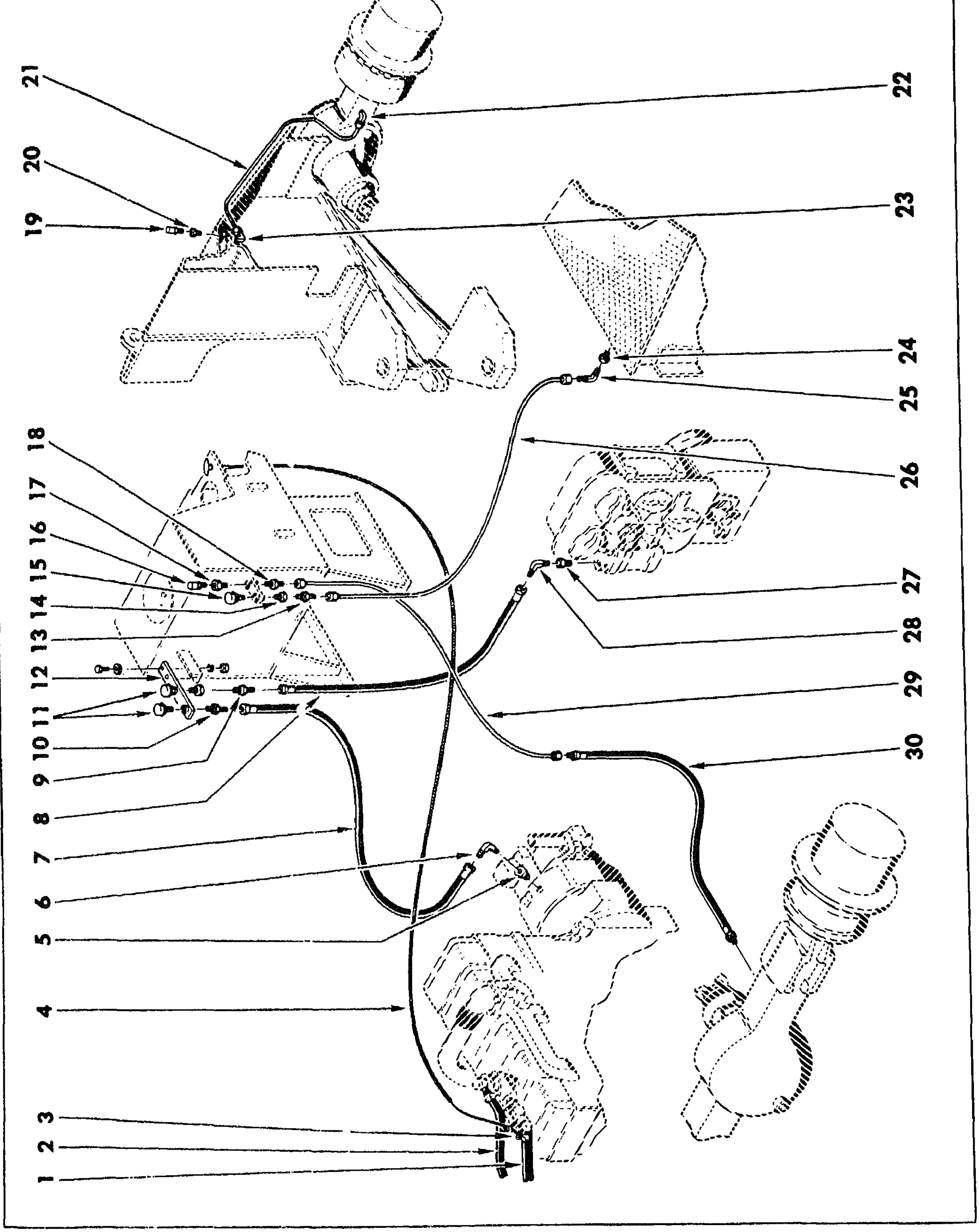
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VENT INSTALLATION

Item	Part No.	Description	No. Req'd.
1	2068245	Hose, Crank Case Vent	1
2	2068246	Hose, Crank Case Vent	1
3	2054765	Clamp, Hose	1
4	2007026	Cable, Water Fording	1
5	2053270	Bushing, Reducer	1
6	2035239	Elbow, 90°	1
7	2067886	Hose, to Converter	1
8	2067885	Hose, to Transmission	1
9	2033927	Adapter, Straight	1
10	2033636	Adapter, Straight	1
11	2049101	Breather, Converter & Transmission	2
12	2067820	Mount, Breather	1
12A	2031475	Bolt	2
12B	2031391	Washer, Lock	2
12C	2031617	Nut	2
13	2033927	Adapter, Straight	1
14	2053263	Bushing, Reducer	1
15	2049101	Breather, Fuel Tank	1
16	2016292	Breather	1
17	2053376	Bushing, Reducer	1
18	2033927	Adapter, Straight	1
19	2016292	Breather	1
20	2053376	Bushing, Reducer	1
21	2067888	Tube Assy.	1
22	2031996	Elbow, 45° Adapter	1
23	2034486	Elbow, 90° Adapter	1
24	2053263	Bushing, Reducer	1
25	2036538	Elbow, 45° Adapter	1
26	2067891	Tube Assy.	1
27	2053263	Bushing, Reducer	2
28	2036538	Elbow, 45°	1
29	2067890	Tube Assy.	1
30	2068187	Hose, to Rear Axle	1

ress the oil seal (24) from the cover.

nsert puller screws into the threaded holes in the flange f the bearing cage to pull the cage and drive pinion ssembly from the carrier. Remove and wire together e shims (10) removed from the carrier.

AUTION: Do not use a pinch bar to pry the bearing cage and drive pinion from the carrier as this may distort the shims. Do not attempt to drive the pinion shaft and cage from the carrier or this will distort the retaining ring groove of the drive pinion.

ress the drive pinion from the bearing cage. Remove e outer bearing cone (25) from the bearing cage. ress the bearing cone (13) from the drive pinion. Re- ove the lock ring (29) and retaining ring (11) from e drive pinion and press the rear bearing (12) from e pinion.

IOTE: The drive pinion forward bearing cage, cup, cone, and spacer assembly are sold as a complete unit to insure that the proper preload (5 to 15 lbs. in. torque) is obtained when reassembling. We do not recommend replacement of individual parts. (Order Item E in parts listing.)

RIVE GEAR AND PINION

hould it be necessary to replace the drive gear and inion assembly, order Item D from parts listing.

ING GEAR

emove ring gear as follows: Carefully center punch ivets in center of head. Using a drill 1/32-inch smaller an body of rivet, drill through head of rivet. Press ivets from ring gear and case half.

AUTION: Do not attempt to pry or chisel rivets from ring gear or case half.

IFFERENTIAL CLEANING AND NSPECTION

lean parts with ground and polished surfaces, includ- g gears, bearings, shafts, and collars with a suitable lvent such as kerosene or diesel fuel.

AUTION: Do not clean parts with gasoline. Do not use a hot solution tank or strongly alkaline water solutions containing sodium hydroxide, orthosilicates, or phosphates to clean ground and polished parts. Do not steam-clean parts after they have been removed from the axle housing. This will cause corrosion of close tolerance parts and also cause rust particles to become entrained in the lubricating oil.

ry all parts immediately after cleaning, using soft, ntless paper towels or wiping rags. Prevent lapping ompound, metal filings, or contaminated oils from en-

IMPORTANT: Many parts are sold only in combination with other parts because they are matched sets. Do not attempt to replace these parts singly.

Carefully inspect all bearing cups and cones for wear, scoring, pitting, or other damage.

Inspect side gears, spider gears, and the drive gears for wear and damage. Replace gears that are scored, pitted, ridged, galled, or worn.

Inspect thrust washers for pitted, worn, or scored thrust surfaces. Always replace thrust washers in sets. Combinations of new and used thrust washers will cause premature failure.

Replace lockwashers, snap rings, oil seals, gaskets, and similar expendable parts at each overhaul.

Remove nicks, mars, and burrs from machined or ground surfaces with a fine mill file or India stone. Make sure all threaded parts are clean in order that all parts may be properly adjusted and torqued. Remove all burrs caused by lockwashers to assure easy reassembly of parts.

DIFFERENTIAL REASSEMBLY AND INSTALLATION

Refer to the differential group illustration for parts identification.

If any of the individual parts of the pinion forward bearing cage assembly (13, 14, 15, 25, 26 or 27) are damaged, obtain a new assembly.

Remove bearing cone (13) from assembly. Press bearing (13) onto drive pinion (28).
Press rear bearing (12) onto the drive pinion (28); secure the rear bearing with a retaining ring (11) and lock ring (29). When pressing bearing onto the shaft, use a suitable driver that will apply force only against the inner race.

Insert the drive pinion and bearing assembly into the bearing cage and position the spacer (14) on the pinion shaft. Press the bearing cone (25) onto the pinion shaft so that the bearing is fully seated against the spacer. Rotate the cage several revolutions to assure normal bearing contact.

With the bearing still under press pressure, check the bearing preload torque by wrapping a soft wire around the bearing cage and pull off in a straight line using a pound scale. (See Fig. 6). The rotating torque (not starting torque) must be between 5 and 15 lb. in. Determine the torque in pound inches as follows:

Assuming that the bearing cage has a diameter of 6 inches, the radius is then 3 inches. If the pull required to maintain rotation of the bearing cage is 5 pounds, multiply the number of pounds by the radius to get $5 \times 3 = 15$ lb. in. of preload torque.

to 1100 lb. ft. torque on front axle and 700 to 900 lb. ft. on rear axle. Recheck to see that rotating torque is between 5 and 15 lb. in.

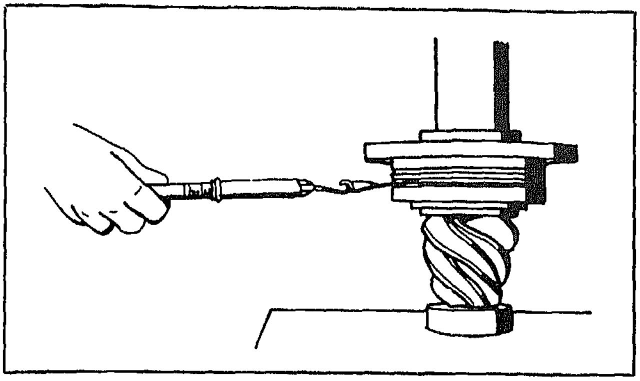


Fig. 109. Measuring Pinion Bearing Preload

When the rotating torque is correct, remove drive pinion assembly and install the shims (10) between the carrier and bearing cage. With suitable puller, remove companion yoke (23) from pinion (28). Press a new oil seal (24) into the oil seal cover (17) and install the oil seal and cover assembly and gasket (16) on the bearing cage so that all holes are properly aligned with the mounting holes on the carrier. Secure with bolts (19), and lockwashers (18) on the rear axle]. Torque bolts to 81 to 104 lb. ft.

Reinstall the companion yoke, securing it with a washer (20) and nut (21). Torque to 800 to 1100 lb. ft. on front axle and 700 to 900 lb. ft. on rear axle.

REASSEMBLY OF DRIVE GEAR AND CASE HALF

Rivet drive gear to case half with new rivets. Rivets should NOT be heated. When the correct rivet is used, the head being formed by pressing will be at least ⅛-inch larger in diameter than the rivet hole. The head, pressed, will then be approximately the same height as the preformed head.

Correct tonnage pressure required to squeeze rivets is 45.

Lubricate the inner walls of the differential cases (5 and 41) and all differential parts with axle lubricant. Position the thrust washer (35) and side gear (34) in the flanged case half. Install the gear (32) and thrust washers (30) on the spider and position the spider assembly on the side gear in the case half. Install the other side gear and thrust washer on the spider assembly and install the plain case half (41), being sure to align matchmarks. Secure case halves together with four bolts (47), [and nuts (40) and lockwashers, evenly spaced on the front axle]. Check for free rotation of the differential gears and correct any binding. After free rotation is assured, install the remaining bolts (47) [and nuts (40) and lockwashers, on the front axle] and tighten to 185 to 235 lb. ft. torque.

bores. It must be a hand-push fit. If it is not, rework t bores with a scraper or with emery cloth until a har press fit is attained. Use a blued bearing cup to che the fit as the work progresses. When correct fit is tained remove the bearing caps and related parts.

Coat the differential bearing cups and cones with r axle lubricant. Position the bearing cups on the beari cones and position the differential assembly on differential carrier. Install the bearing adjusting rin (1 and 37) and hand-tighten them against the beari cups. Install the bearing caps (43 and 46). Tap ligh into position, being certain the matchmarks are align Take care to prevent cross-threading of adjustment nu Secure bearing caps with bolts and flat-washers. Torq bolts to 470 to 595 lb. ft. on front axle and 160 to 2 lb. ft. on rear axle.

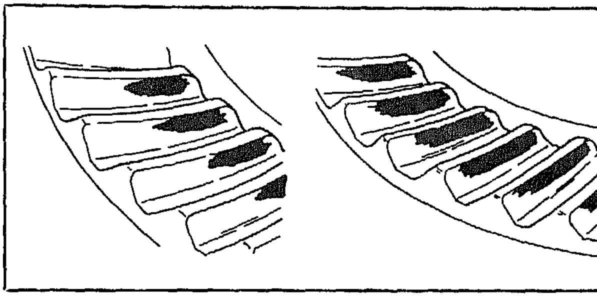
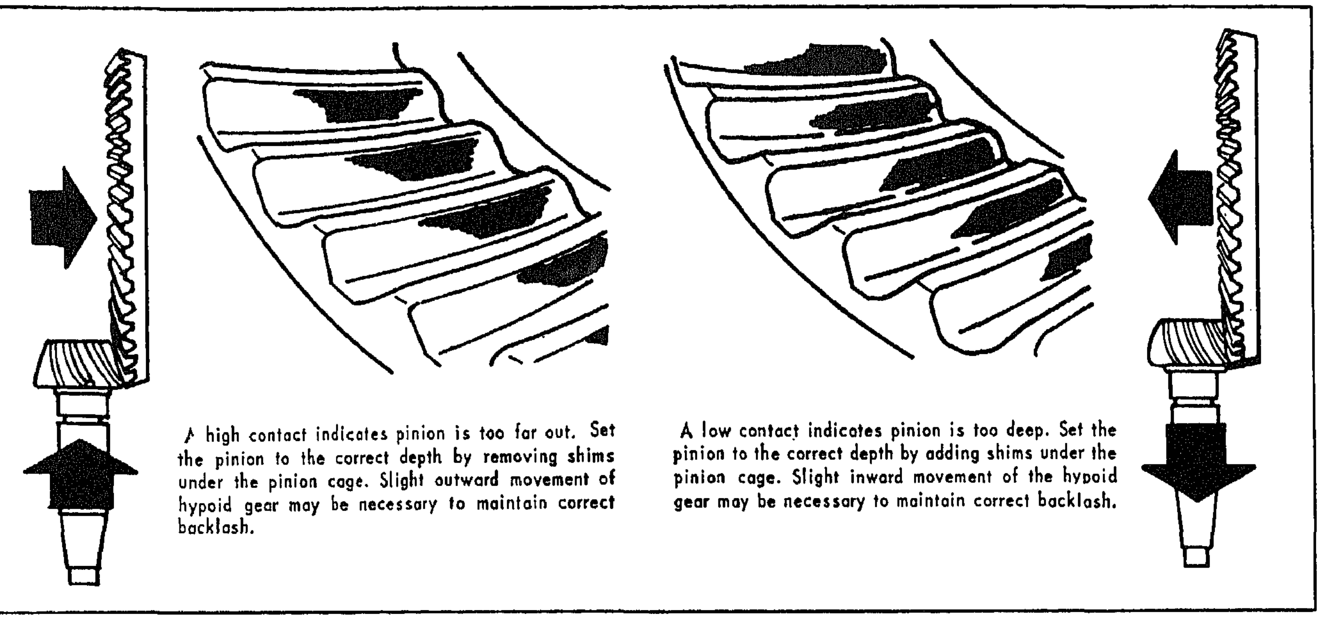


Fig. 110. Differential Tooth Contact Pattern

Mount a dial indicator to check the back face of t drive gear (42). Loosen the bearing adjusting ring (3 opposite the drive gear until the dial indicator indica some end play. Tighten the same nut just enough that the dial indicator indicates no end play. Rotate t differential to check the back of the drive gear for ru out. If runout exceeds .008 inch, remove the different and check for cause of the excessive runout. Tight the adjusting nut one notch to preload the different bearings.

Install a dial indicator to check backlash of the dri gear. If the old drive gear and pinion are being use adjust the backlash to the amount noted before d assembly. If a new gear set is used, adjust the backla to .010-inch. Backlash is adjusted by backing off o adjusting ring and advancing the opposite ring t same amount.

When proper backlash is adjusted, apply oiled red le to approximately twelve teeth of the drive gear (4 with a paint brush. Rotate the pinion to squeeze the r lead from the teeth in the tooth contact areas, leavi bare the exact size, shape, and location of the conta Apply a small amount of resistance to the rotation the gear using a flat steel bar and rotate the pinion w a wrench to obtain a sharper tooth contact impressio Refer to the tooth contact illustration in Figs. 110 & 1 for a proper tooth contact pattern and for adjustmen required to correct an improper tooth contact patte



A high contact indicates pinion is too far out. Set the pinion to the correct depth by removing shims under the pinion cage. Slight outward movement of hypoid gear may be necessary to maintain correct backlash.

A low contact indicates pinion is too deep. Set the pinion to the correct depth by adding shims under the pinion cage. Slight inward movement of the hypoid gear may be necessary to maintain correct backlash.

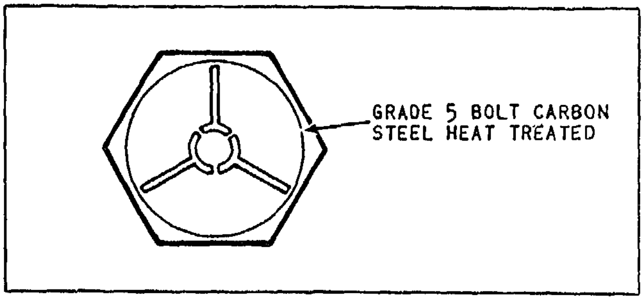
Fig. 111. Differential Tooth Contact Adjustments

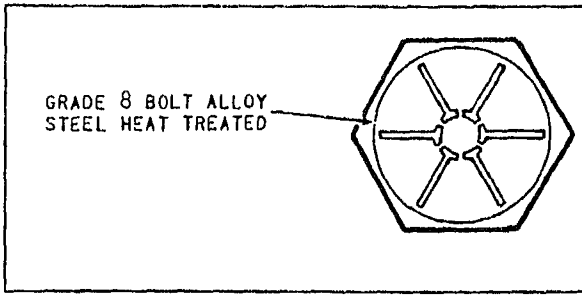
fter obtaining a satisfactory tooth contact, especially relation to the top and bottom of the tooth, the acklash can be altered within limits of .005 to .015 inch obtain better tooth contact along the length of the ooth. A high backlash setting will keep the contact om starting too close to the toe. A low backlash setng will keep contact from starting too far away from e toe. Establish the proper backlash by adjusting the ositions of the adjusting rings. After proper adjustent, install the cotter pins to lock the adjusting rings the required positions.

emove the differential and carrier assembly from the and, and position it on a bench with the back face of e drive gear (42) up. Remove the adjusting screw (7) d locknut (8) from the rear axle. Place the thrust ock (6) from the rear axle on the rear face of the rive gear and rotate the drive gear until the hole in e thrust block is aligned with the adjusting screw ole. Install the adjusting screw and locknut and tighten the adjusting screw until the thrust block is firmly against the back face of the drive gear; then loosen the adjusting screw one-fourth turn and lock securely with the locknut (8). This should provide .010 to .015 inch between the thrust block and drive gear. Recheck to assure that there is full .010 inch clearance between the block and gear during the full revolution of the bevel gear.

To lubricate the differential, fill the axle housing to the level specified in the lubrication chart. Be sure the universal joint is also properly lubricated. Jack up both rear wheels. With the transmission shifted in high range, run the vehicle at moderate speed for 5 minutes to assure satisfactory lubrication of all differential and carrier parts. Never operate the unit with only one wheel jacked up; this causes all torque to be transferred to that wheel and results in overheating of the differential spider and galling and shearing of the spider pins.

markings on their heads.

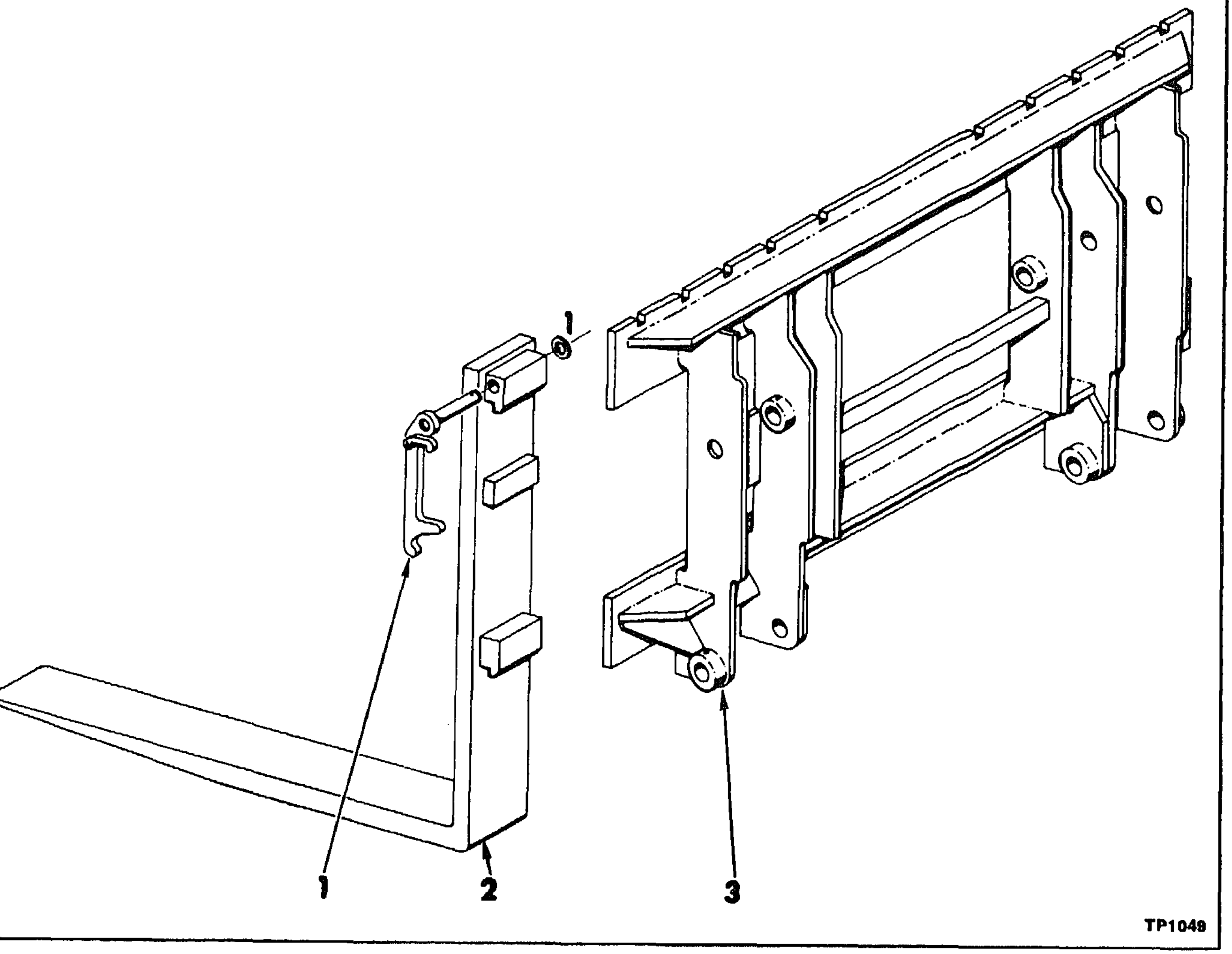




BOLT TORQUE

THREAD SIZE	HEX SIZE	TORQUE (Lbs.-Ft.) SAE GRADE 5		TORQUE (Lbs.-Ft.) SAE GRADE 8	
	Bolt & Nut	Dry	Oiled	Dry	Oiled
1/4-20	7/16	5	4	9	7
1/4-28	7/16	6	5	12	9
5/16-18	1/2	10	7	20	15
5/16-24	1/2	13	10	25	19
3/8-16	9/16	18	13	36	27
3/8-24	9/16	24	18	47	35
7/16-14	5/8 & 11/16	33	25	59	44
7/16-20	5/8 & 11/16	37	28	74	55
1/2-13	3/4	47	35	91	68
1/2-20	3/4	60	45	117	88
9/16-12	13/16 & 7/8	68	51	132	100
9/16-8	13/16 & 7/8	86	65	166	125
5/8-11	15/16	95	71	181	136
5/8-18	15/16	124	93	240	180
3/4-10	1-1/8	175	131	340	255
3/4-16	1-1/8	218	163	424	318
3/4-16 WHEEL MOUNTING TORQUE ☛				500	
7/8-9	1-5/16	286	214	555	415
7/8-14	1-5/16	344	258	679	510
1"-8	1-1/2	428	320	836	626
1"-14	1-1/2	545	410	1058	790
1-1/8-7	1-11/16	605	455	1175	880
1-1/8-12	1-11/16	768	575	1494	1120
1-1/4-7	1-7/8	878	660	1705	1280
1-1/4-12	1-7/8	1080	810	2115	1580
1-3/8-6	2-1/16	1265	950	2455	1840
1-3/8-12	2-1/16	1635	1230	3180	2380
1-1/2-6	2-1/4	1551	1130	3011	2260
1-1/2-12	2-1/4	1972	1480	3830	2870

Use Grade 5 Torques on ordinary fasteners. Use oiled column when white lead is used. Use Grade 8 Torques for propeller shaft bolts.



FORK LIFT ATTACHMENT

Item	Part No.	Description	No. Req'd.
1	2067547	Lock Assy., L.H.	1
1	2067546	Lock Assy., R.H. (N.I.)	1
1A	2037288	Pin, Cotter	2
1B	2068581	Washer, Flat	2
2	2067553	Fork Assy.	1
3	2067516	Carriage Assy., Fork	1
4	2064550	Bar, Tie Down (Carriage to Main Frame) (N.I.)	1
4A	2031578	Bolt (N.I.)	2
4B	2031396	Washer, Lock (N.I.)	2
4C	2031622	Nut (N.I.)	2

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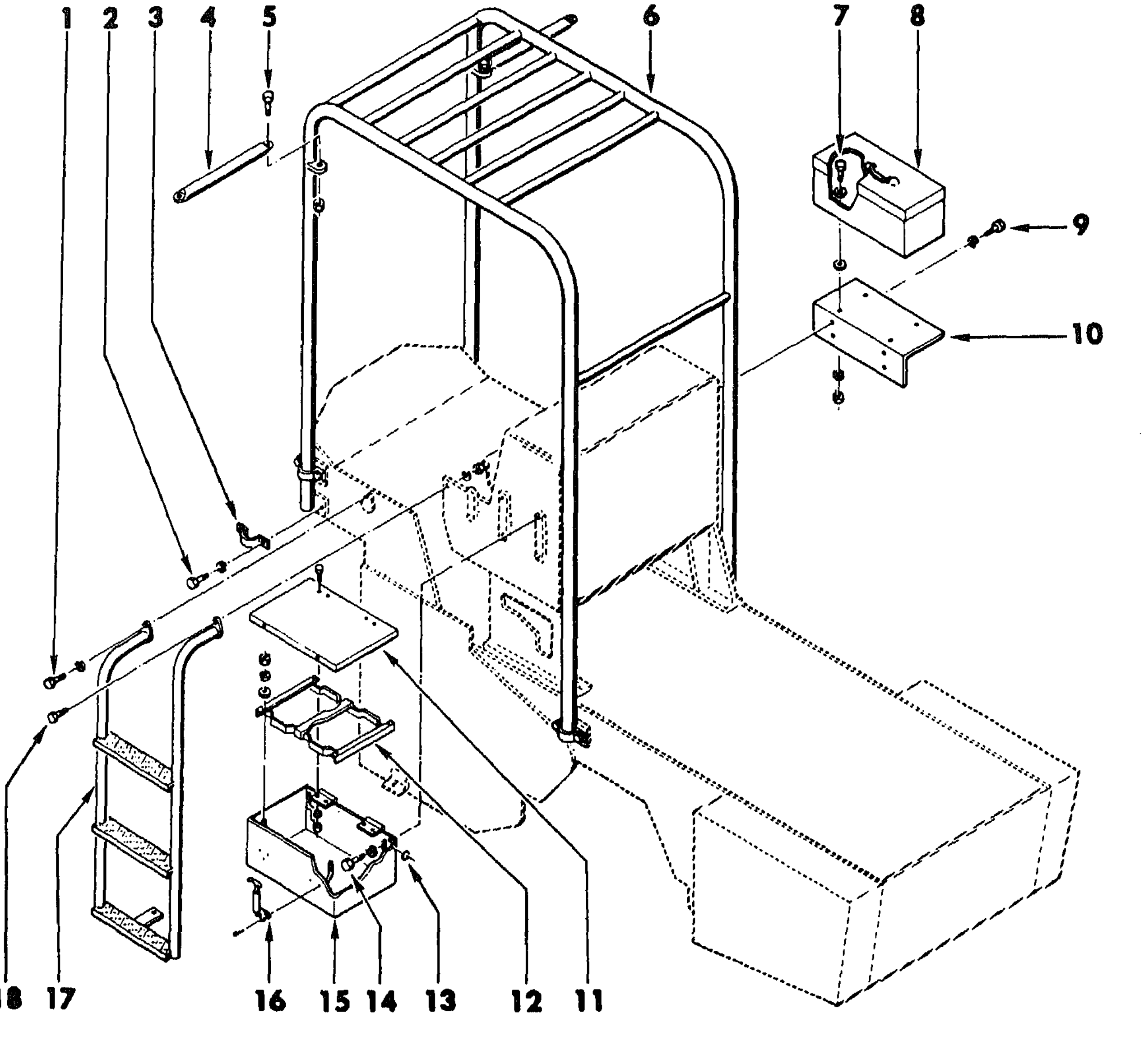
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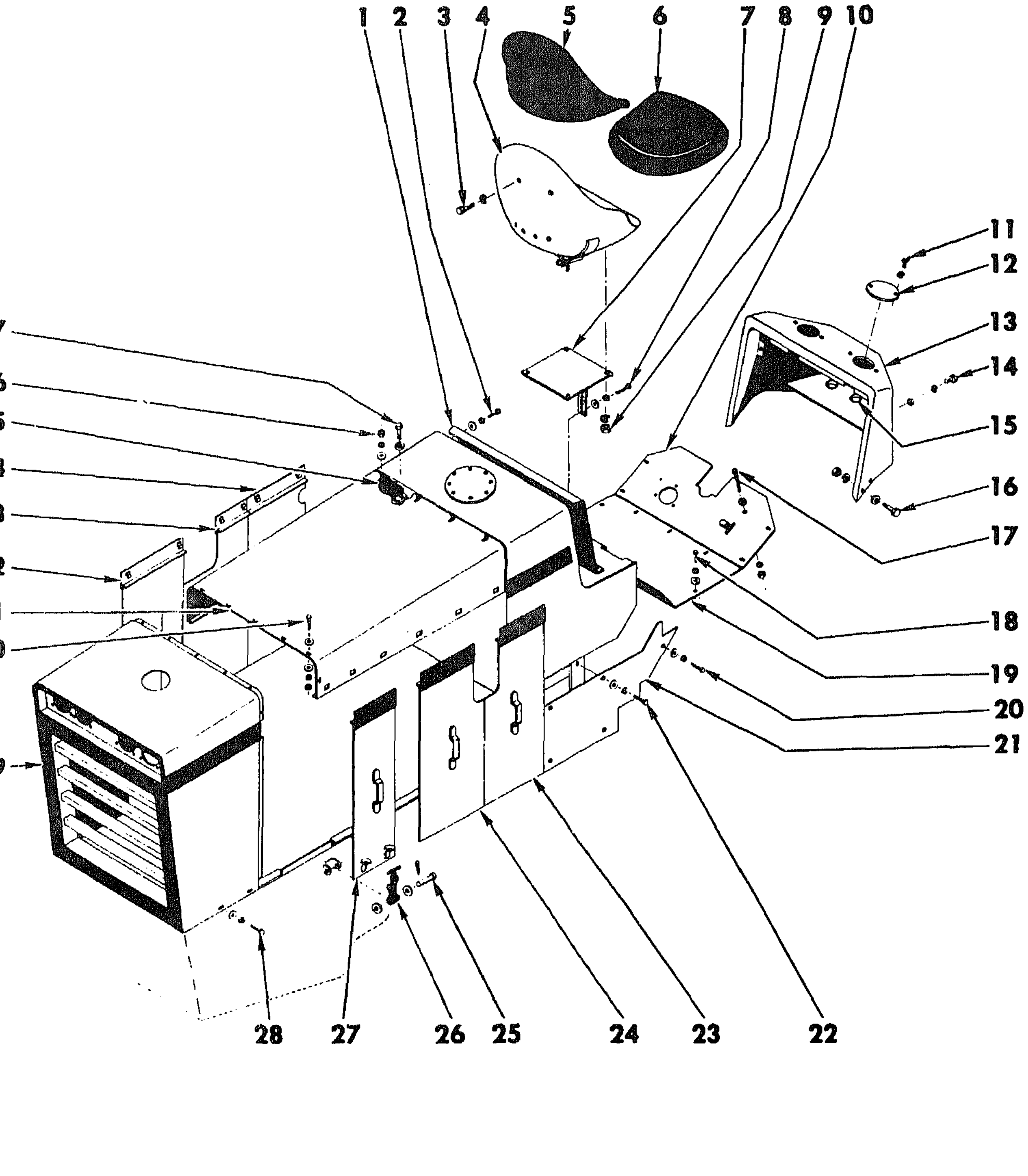
OVERHEAD GUARD ASSEMBLY

Item	Part No.	Description	No. Req'd.
1	2031517	Bolt, Hand Rail to Frame	1
1A	2031393	Washer, Lock	1
2	2031517	Bolt, Clamp to Frame	12
2A	2031393	Washer, Lock	12
3	2067805	Clamp, Guard to Frame	6
4	2068315	Arm, Support	2
5	2031520	Bolt	2
5A	2067435	Nut, Locking	2
6	2067759	Guard Assy., Overhead (Incl. Items 4 & 5)	1
7	2031475	Bolt, Tool Box to Mount Bracket	4
7A	2032960	Washer, Flat	8
7B	2031391	Washer, Lock	4
7C	2031617	Nut	4
8	2041624	Box, Tool	1
8A	2030337	Wrench, Spanner, Hook Type	1
8B	2015362	Wrench, Spanner, Hook Type	1
8C	2060445	Wrench, Spanner, Hook Type	1
8D	2030340	Wrench Assy., Wheel	1
8E	2030341	Socket	1
8F	2030342	Handle	1
8G	2053113	Wrench, Main Filter	1
8H	2062739	Gun, Grease	1
8I	2039106	Wrench, Wheel Bearing Nut	1
8J	2067838	Gauge, Tire	1
9	2031517	Bolt, Bracket to Hyd. Tank	4
9A	2031393	Washer, Lock	4
10	2067804	Bracket Assy., Mount	1
11	2067748	Cover, Battery Box (Incl. Items 11A, 11B & 11C)	1
11A	2031426	Bolt, Cover to Hinge	4
11B	2031389	Washer, Lock	4
11C	2031615	Nut	4
12	2064485	Retainer, Battery	1
12A	2032959	Washer, Flat	4
12B	2031390	Washer, Lock	4
12C	2031370	Nut	4
13	2044426	Grommet	2
14	2031517	Bolt, Battery Box to Hydraulic Tank	6
14A	2031393	Washer, Lock	6
15	2067747	Plate Assy.	1
15A	2067654	Box Assy., Battery (Incl. Items 11 thru 11C)	1
16	2033271	Fastener, Hood	2
16A	2054860	Screw, Drive	6
17	2067983	Ladder Assy.	1
18	2031519	Bolt, Hand Rail to Tank & Step to Frame	2
18A	2031393	Washer, Lock	2
18B	2031619	Nut	2



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SHEET METAL GROUP

Item	Part No.	Description	No. Req'd.
1	2058660	Shield, Hydraulic Heat	1
2	2031473	Bolt	6
2A	2031391	Washer, Lock	6
2B	2032960	Washer, Flat	6
3	2031472	Screw, Cap	7
3A	2036816	Washer, Flat	7
4	6951723	Shell & Slide Assy.	1
5	6951721	Rest Assy., Back	1
6	6951722	Cushion Assy., Seat	1
7	2046363	Support Assy., Seat	1
8	2031475	Bolt	2
8A	2031477	Bolt	2
8B	2032960	Washer, Flat	4
8C	2031391	Washer, Lock	4
9	2031370	Nut	4
9A	2031390	Washer, Lock	4
10	2058971	Floorplate Assy., Front	1
11	2040935	Fastener, Wing Type	4
11A	2040936	Washer, Retainer	4
12	2049130	Plate, Inspection, front Shroud & Hyd. Tank	4
12A	2031450	Bolt, Plate to Hydraulic Tank (N.I.)	4
12B	2031390	Nut (N.I.)	4
13	2067736	Shroud Assy., Front	1
14	2031474	Bolt	3
14A	2031391	Washer, Lock	3
14B	2032960	Washer, Flat	3
15	2044426	Grommet, Rubber	2
16	2031477	Bolt	4
16A	2032960	Washer, Flat	4
16B	2031391	Washer, Lock	4
16C	2031616	Nut	4
17	2031485	Bolt, Pedal Stop	1
17A	2031391	Washer, Lock	1
17B	2031617	Nut	2
18	2031475	Bolt	11
18A	2031391	Washer, Lock	
18B	2032960	Washer, Flat	
19	2067785	Floorplate	
20	2031515	Bolt	
20A	2031393	Washer, Lock	
20B	2032962	Washer, Lock	
21	2067893	Panel, R.H. Side	
21A	2067894	Panel, L.H. Side (N.I.)	
22	2031473	Bolt	
22A	2031391	Washer, Lock	
22B	2032960	Washer, Flat	
23	2065314	Panel, Side, R.H. Front	
24	2065316	Panel, Side, R.H. Center	
25	2062539	Pin	
25A	2036811	Washer	
25B	2031757	Pin, Cotter	
26	2064185	Latch	
27	2065318	Panel, Side, R.H. Rear	
28	2031520	Bolt	
28A	2031393	Washer, Lock	
28B	2032962	Washer, Flat	
28C	2031619	Nut (N.I.)	
29	2067929	Cowl Assy., Rear	
30	2031473	Bolt, Hood to [illegible]	
30A	2031391	Washer, Lock	
30B	2032960	Washer, Flat	
30C	2031617	Nut	
31	2067396	Hood Assy.	
32	2065319	Panel, Side, L.H. Rear	
33	2065317	Panel, Side, L.H. Center	
34	2068267	Panel, Side, L.H. Front	
35	2067397	Mount, Shock	
36	2031616	Nut	
36A	2032959	Washer, Flat	
37	2031452	Bolt, Shock Mount to Hydraulic Tank	
37A	2031390	Washer, Lock	

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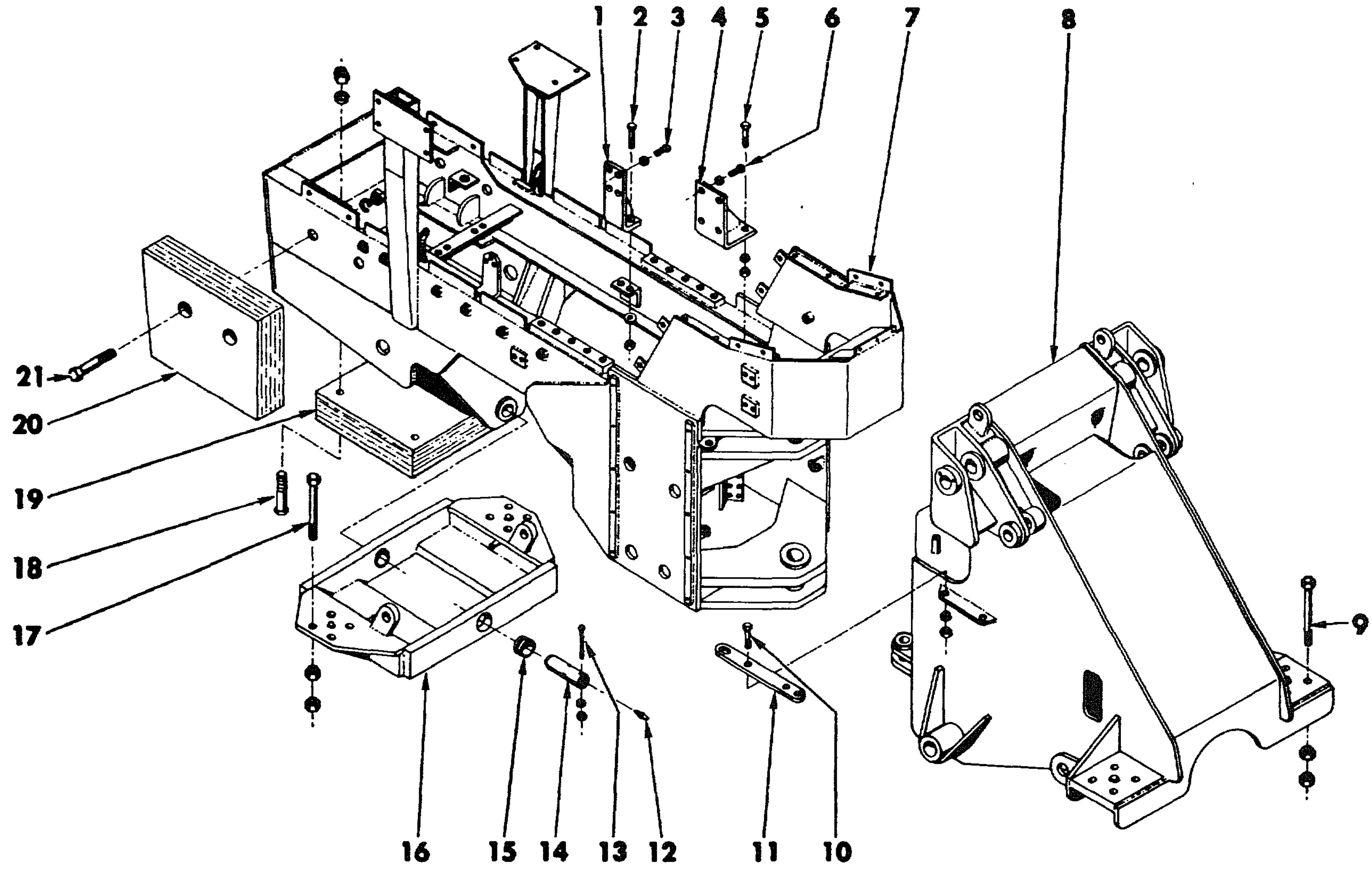

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FRAME

Item	Part No.	Description	No. Req'd.
1	2049330	Support Assy., Engine Rear	2
2	2030896	Bolt, Support to Frame	4
2A	2032965	Washer, Flat	4
2B	2058996	Nut	4
3	2037660	Bolt, Engine to Support	8
3A	2031393	Washer, Lock	8
4	2060026	Bracket Assy., Transmission	2
5	2031579	Bolt, Bracket to Frame	4
5A	2032965	Washer, Flat	4
5B	2067438	Nut	4
6	2031577	Bolt, Transmission to Bracket	8
6A	2031396	Washer, Lock	8
7	2067811	Frame Assy., Rear	1
8	2067874	Frame Assy., Front	1
9	2041619	Bolt, Axle to Frame	8
9A	2034195	Pin, Dowel (N.I.)	2
9B	2031380	Nut	16
10	2031579	Bolt	4
10A	2031396	Washer, Lock	4
10B	2031622	Nut	4
11	2060762	Bar, Tie Down	2
12	2033249	Fitting, Grease, 90°	2
13	2031416	Bolt	2
13A	2031395	Washer, Lock	2
13B	2031619	Nut	2
14	2061799	Pin	2
15	2061806	Bushing	2
16	2067927	Axle Carrier Assy.	1
16A	2044345	Spacer (Thick) (N.I.)	AR
16B	2044346	Spacer (Thin) (N.I.)	AR
16C	2034012	Pin, Dowel (N.I.)	2
17	2032463	Bolt	8
17A	2031378	Nut	16
18	2068180	Bolt	4
18A	2032967	Washer, Flat (N.I.)	4
18B	2031398	Washer, Lock	4
18C	2031624	Nut	4
19	2067948	Counteweight	1
20	2067946	Counterweight, R.H.	1
20A	2067947	Counterweight, L.H. (N.I.)	1
21	2068182	Bolt	4
21A	2031400	Washer, Lock	4
21B	2031626	Nut	4
22	2067883	Pin, Drawbar (N.I.)	1
22A	2067881	Clip, Hitch Pin N.I.)	1

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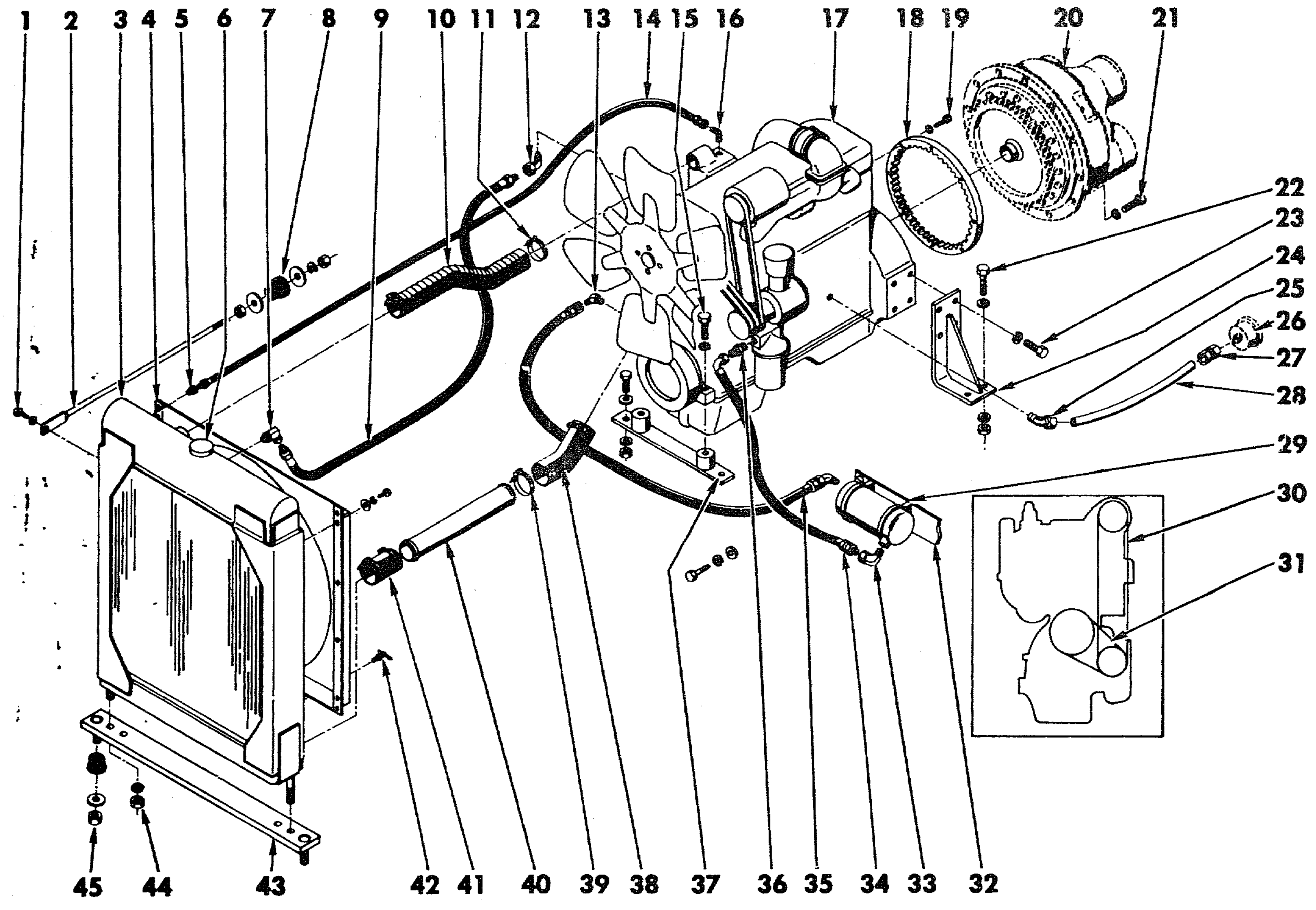
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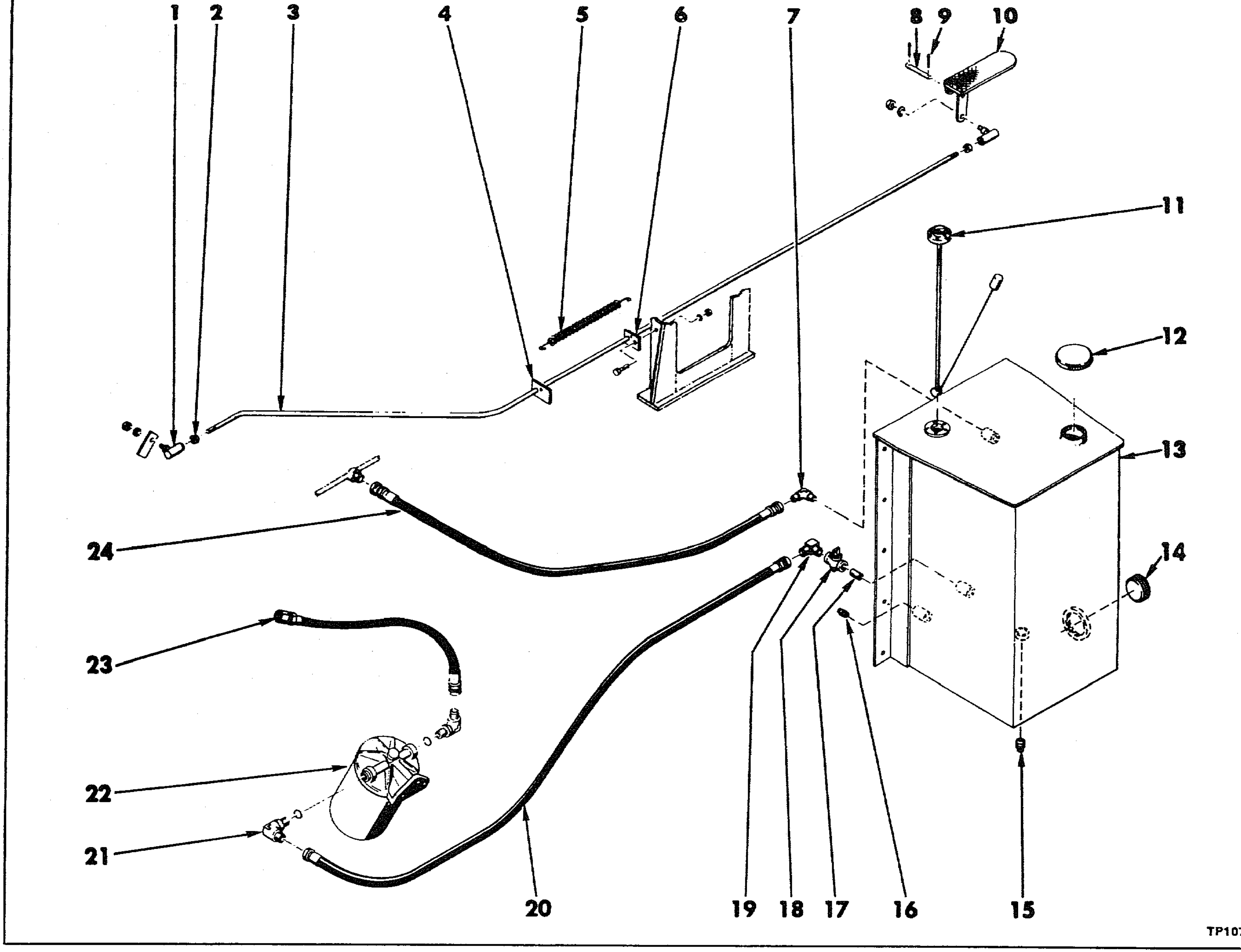
ENGINE AND RELATED PARTS

Item	Part No.	Description	No. Req'd.
1	2031517	Bolt	2
1A	2031393	Washer, Lock	2
2	2064208	Brace Assy., Radiator	2
3	2065134	Radiator	1
4	2039670	Shroud, Fan	1
4A	2031427	Bolt	8
4B	2031389	Washer, Lock	8
4C	2032958	Washer, Flat	8
5	2033038	Bushing, Reducer	1
6	2055049	Cap, Filler	1
7	2031895	Elbow, 45°	1
8	2049889	Shockmount	2
8A	2041570	Washer, Flat	2
8B	2031393	Washer, Lock	2
8C	2031373	Nut	2
9	2057571	Hose	1
10	2003766	Hose, Upper	1
11	2032040	Clamp	2
12	2032296	Elbow, 90°	1
13	2036543	Elbow, 45°	1
14	2046560	Hose	1
15	2037701	Bolt	2
15A	2031395	Washer, Lock	2
16	2031996	Elbow, Adapter, 45°	1
17	2067794	Engine Assy.	1
17A	2068289	Starter (Furnished with Engine) (N.I.)	1
17B	2068290	Generator (Furnished with Engine) (N.I.)	1
17C	2068291	Regulator (Furnished with Engine) (N.I.)	1
17D	2059714	Fan (Furnished with Engine) (N.I.)	1
17E	2059715	Trunnion Mount, Front (Furnished with Engine) (N.I.)	1
17F	2059716	Belts, Drive (Furnished with Engine) (N.I.) (Matched Set of 2)	1
18	2039266	Gear Assy., Ring	1
19	2039267	Bolt	8
19A	2039268	Washer	8
20	———	Converter, Torque (See Sep. Illus.)	
20A	2067859	Gasket (N.I.)	1
21	2031477	Bolt	12
21A	2031391	Washer, Lock	12

(N.I.) Not Illustrated

Item	Part No.	Description	No.
22	2032221	Bolt, Support to Frame	
22A	2032964	Washer, Flat	
22B	2067428	Nut, Self Locking	
23	2037660	Bolt, Support to Engine	
23A	2031393	Washer, Lock	
24	2049330	Support Assy., Engine (Rear)	
25	2049707	Elbow, 45°	
26	———	Gauge, Oil Pressure (See Instrument Panel Illus.)	
27	2051701	Connector, Female	
28	2062413	Tube	
29	———	Refiner, Oil (Furnished with Engine)	
29A	2031452	Bolt	
29B	2031390	Washer, Lock	
29C	2031616	Nut	
30	2068227	Belt, Generator	
31	2059716	Belt, Fan (Matched Set of 2)	
32	2067378	Plate, Mount	
32A	2031517	Bolt	
32B	2031393	Washer, Lock	
32C	2032962	Washer, Flat	
33	2032010	Elbow, 90°	
34	2038050	Hose, Filter to Oil Refiner	
35	2049661	Hose, Refiner to Engine	
36	2031988	Connector, Straight	
37	2056826	Mount Assy., Engine, Front	
37A	2037699	Bolt	
37B	2032964	Washer, Flat	
37C	2067437	Nut, Self Locking	
38	2040077	Hose	
39	2032041	Clamp	
40	2040076	Tube	
41	2031424	Hose	
42	2033256	Cock, Drain	
43	2045875	Bar Assy., Radiator	
44	2067435	Nut	
44A	2032962	Washer, Flat	
45	2049889	Shockmount	
45A	2041570	Washer, Flat	
45B	2067435	Nut, Grip	
46	2022412	Filter Element, Fuel (N.I.)	
47	2022413	Filter Element, Oil (N.I.)	



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FUEL TANK, LINES AND ACCELERATOR LINKAGE

Item	Part No.	Description	No. Req'd.
1	2032762	Joint, Ball	2
1A	2031390	Washer, Lock	2
1B	2031616	Nut	2
2	2033514	Nut, Jam	2
3	2059817	Rod, Throttle	1
4	2049610	Clip, Return Spring	1
4A	2031429	Bolt (N.I.)	1
4B	2031389	Washer, Lock (N.I.)	1
4C	2031615	Nut (N.I.)	1
5	2031951	Spring	1
6	2059818	Link	1
6A	2031431	Bolt	1
6B	2031389	Washer, Lock	1
6C	2031615	Nut	1
7	2036543	Elbow, Adapter, 45°	1
8	2031968	Pin	1
9	2031758	Pin, Cotter	2
10	2049926	Pedal Assy., Accelerator	1
11	2063857	Gauge, Fuel	1
11A	2035542	Washer, Lock	4
12	2067858	Cap, Filler	1
13	2067855	Tank, Fuel Assy.	1
13A	2031517	Bolt, Tank to Frame (N.I.)	10
13B	2031393	Washer, Lock (N.I.)	10
14	2062206	Plug, Clean Out	1
15	2033388	Plug, Drain	1
16	2033386	Plug, Tank Coupling	1
17	2036256	Nipple, Pipe	1
18	2002966	Valve, Shut Off	1
19	2032011	Elbow, 90°	1
20	2068264	Hose	1
21	2031916	Elbow, 90°	2
21A	2031960	"O" Ring	2
22	2049550	Filter, Fuel	1
22A	2031479	Bolt, Filter to Mount Angle (N.I.)	3
22B	2031391	Washer, Lock (N.I.)	3
22C	2031617	Nut (N.I.)	3
23	2068263	Hose	1
24	2068281	Hose	1

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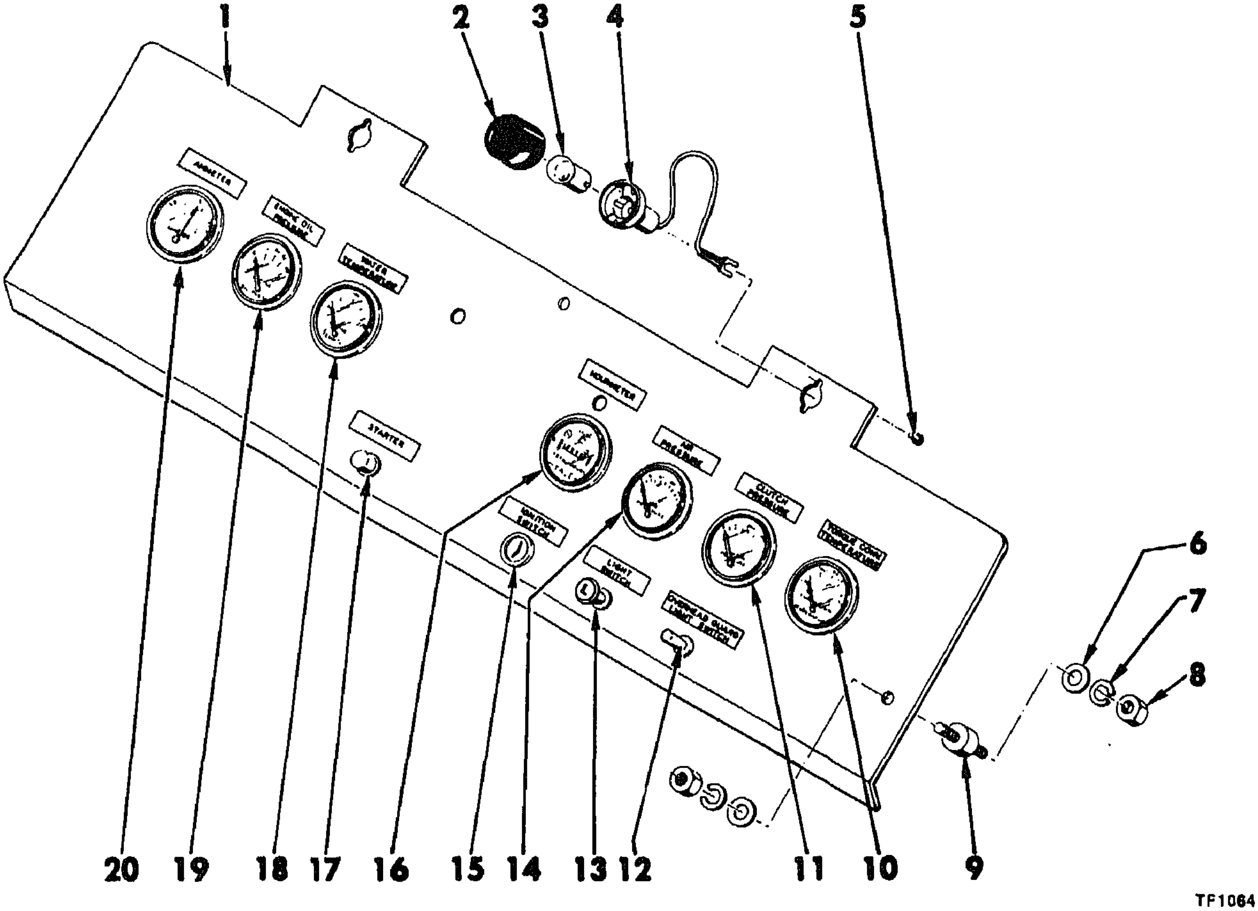


INSTRUMENT PANEL ASSEMBLY

Item	Part No.	Description	No. Req'd.
\	2068364	Identification Tag Kit (Incl. Items 10A, 11A, 12A, 13A, 14A, 15A, 16A, 17A, 18A, 19A & 20A)	1
1	2068322	Panel, Instrument	1
2	———	Shield, Dash Lamp (N.S.S.) (Order Item 4)	2
3	2033929	Bulb	2
4	2033272	Dash Lamp Assy. (Incl. Items 2 & 3)	2
5	2033345	Screw, Sheet Metal	4
6	2032959	Washer, Flat	6
7	2031390	Washer, Lock	6
8	2031616	Nut	6
9	2048525	Shock Mount	3
0	2032693	Gauge, Torque Converter Temp.	1
0A	2065479	Tag, Torque Converter Temperature	1
1	2059340	Gauge, Clutch Pressure	1
1A	2065478	Tag, Clutch Pressure	1
1B	2039440	Nipple, Pipe (N.I.)	1
11C	2032283	Elbow, 45° (N.I.)	1
12	2048492	Switch	1
12A	2068363	Tag, O.H.G. Light Switch	1
13	2052459	Switch, Light	1
13A	2065482	Tag, Light Switch	1
14	2034222	Gauge, Air Pressure	1
14A	2065477	Tag, Air Pessure	1
15	2062644	Switch, Ignition	1
15A	2065483	Tag, Ignition Switch	1
16	2044055	Hourmeter	1
16A	2065474	Tag, Hourmeter	1
17	2042896	Button, Push, Starting Switch	1
17A	2065475	Tag, Starter	1
18	2032694	Gauge, Water Temperature	1
18A	2065473	Tag, Water Temperature	1
19	2032690	Gauge, Engine Oil Pressure	1
19A	2065472	Tag, Engine Oil Pressure	1
20	2057866	Ammeter	1
20A	2065471	Tag, Ammeter	1

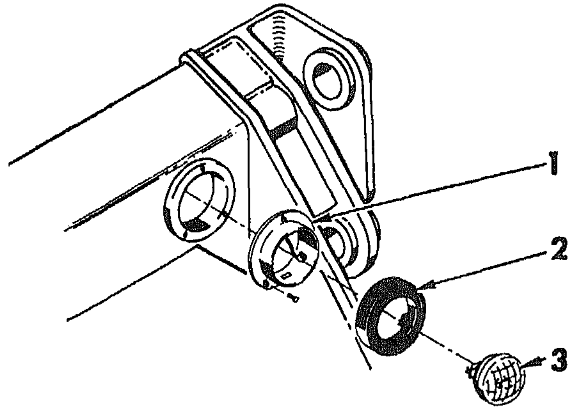
.I.) Not Illustrated

(N.S.S.) Not Seviced Separately

HEAD LIGHT

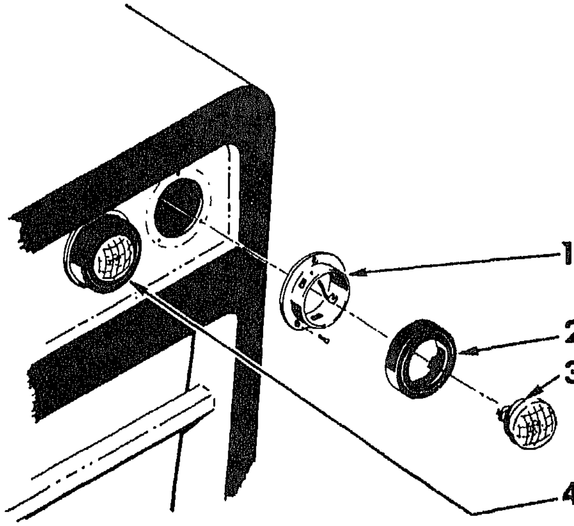
(Two Lights Used Per Machine;
Quantity Shown Is For One).

Item	Part No.	Description	No. Req'd.
A	2048130	Lamp Assy., Front (Incl. Items 1-3)	1
1	6951120	Frame (Incl. Wire & Rivet)	1
1A	6951121	Screw	3
2	6950508	Retainer	1
3	2051982	Lamp	1



TAIL LIGHT AND REAR WORK LIGHT

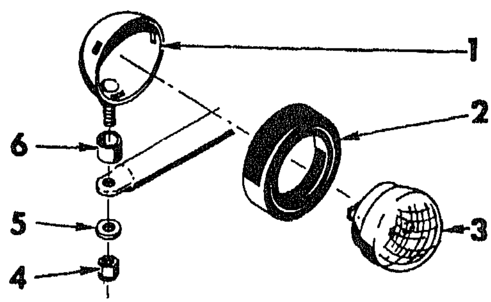
Item	Part No.	Description	No. Req'd.
A	2060809	Light Assy., Stop & Tail (Incl. Items 1, 2 & 3)	2
B	2048130	Rear Work Light (Incl. Items 1, 2 & 4)	2
1	6951120	Frame	4
1A	6951121	Screw	12
2	6950508	Retainer	4
3	6951356	Lamp (Red)	2
4	2051892	Lamp (Clear)	2



OVERHEAD LAMP

(Two Lights Used Per Machine;
Quantity Shown Is For One).

Item	Part No.	Description	No. Req'd.
A	2060810	Overhead Assy. (Incl. Items 1-5)	1
1	6950845	Shell Assy.	1
2	6950508	Retainer	1
3	2051982	Lamp	1
4	2032982	Nut	1
5	6950847	Washer	1
6	6950846	Bushing, Pivot	1



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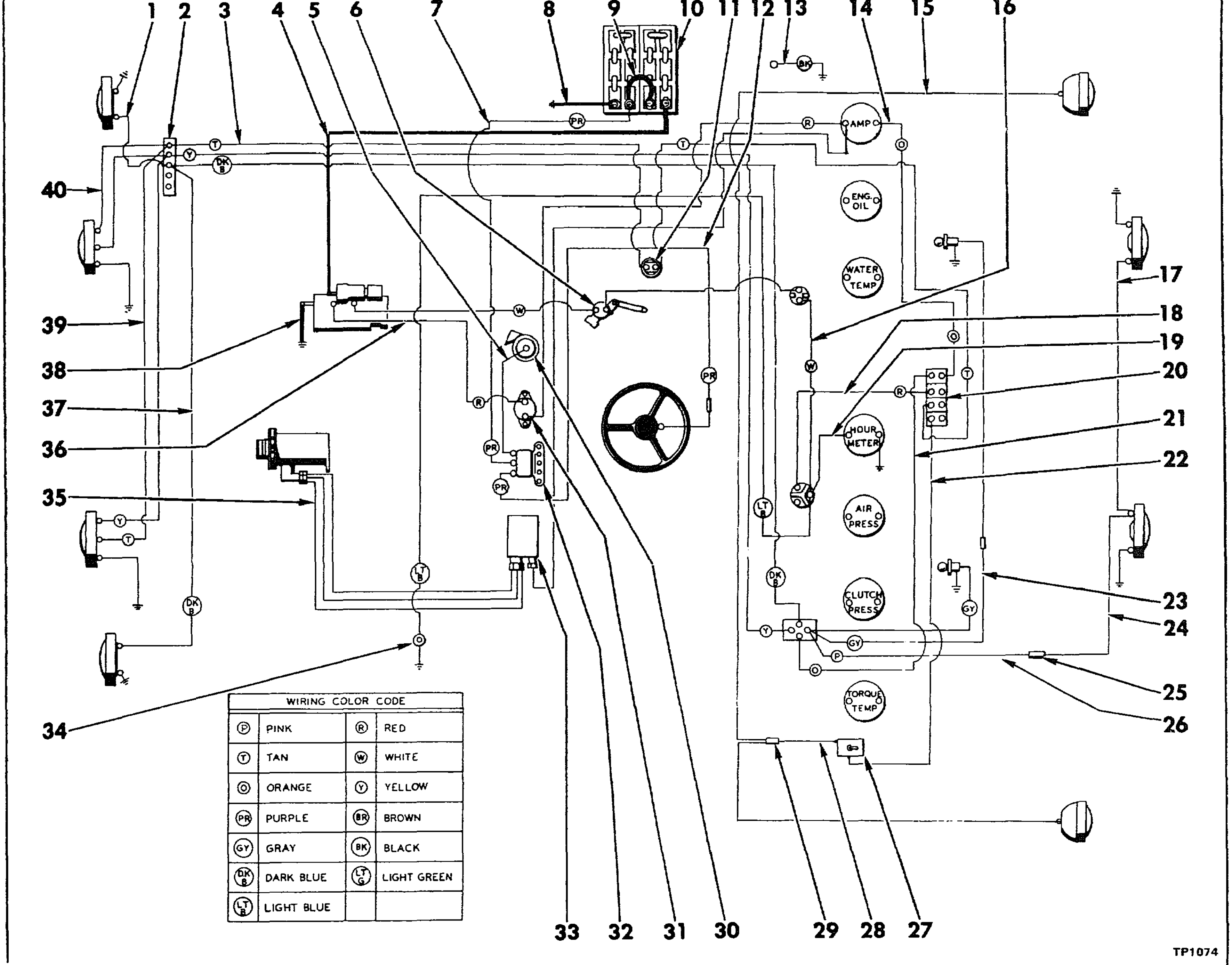

WIRING COLOR CODE			
P	PINK	R	RED
T	TAN	W	WHITE
O	ORANGE	Y	YELLOW
PR	PURPLE	BR	BROWN
GY	GRAY	BK	BLACK
DK B	DARK BLUE	LT G	LIGHT GREEN
LT B	LIGHT BLUE		

BATTERY AND WIRING

Item	Part No.	Description	No. Req'd.
1	2062189	Wire, Terminal Block to Rear Work Light	1
2	2055212	Block, Terminal	1
2A	2031427	Bolt (N.I.)	2
2B	2031389	Washer, Lock (N.I.)	2
2C	2031615	Nut (N.I.)	2
2D	2031866	Washer, Lock (N.I.)	5
2E	2031860	Nut (N.I.)	5
3	2068254	Harness Assy., Main Wiring	1
3A	2068241	Plug Assy. (N.I.)	1
3B	2068307	Adapter (N.I.)	1
3C	2068308	Clamp (N.I.)	1
4	2059994	Cable, Battery to Starter	1
5	2057921	Wire, Horn Relay to Horn	1
6	2033502	Switch, Safety	1
7	2059995	Wire, Battery to Horn Relay	1
8	2057813	Cable, Battery to Ground	1
9	2033412	Cable, Battery Jumper	1
10	2049362	Battery, 12 Volt, 100 Amp Hr.	2
11	2046238	Switch, Stop Light	1
12	2057942	Wire, Horn Relay to Column	1
12A	2061968	Bracket, Wiring Harness	1
12B	2031475	Bolt, Bracket to Front Shroud	1
12C	2031391	Washer, Lock	1
12D	2031617	Nut	1
13	2067058	Wire, Instrument Panel Ground	1
14	2057731	Wire, Ammeter to 30 Amp. Breaker	1
15	2068499	Wire, Connector to Right Light	1
15	2068498	Wire, Connector to Left Light	1
15A	2068505	Grommet	2
16	2051219	Wire, Ignition Switch to Starter Button	1
17	2059997	Wire, Headlight Jumper	1
18	2057728	Wire, 15 Amp. Breaker to Ignition Switch	1
19	2057729	Wire, Ignition Switch to Hourmeter	1
20	2057049	Gang Breaker, Circuit	1
20A	2031429	Bolt, Breaker to Panel (N.I.)	2
20B	2031615	Washer, Lock (N.I.)	2
20C	2031389	Nut (N.I.)	2
21	2057727	Wire, 30 Amp. Breaker to Light Switch	1
22	2058273	Wire, 15 Amp. Breaker to Overhead Light Switch	1
23	2061979	Wire, Light Switch to Panel Light	1

Item	Part No.	Description
24	2059996	Wire, Line Connector to Headlight
25	2050575	Connector, Line, Headlamp, Horn & Dash Lamp
26	2057725	Wire, Light Switch to Line Connector
27	2048492	Switch, Light Overhead Guard
28	2068497	Wire, Overhead Guard Light Switch to Connec.
28A	2068326	Clamp, Wire to Support Arm (N.I.)
29	2068352	Connector
30	2048655	Horn
30A	2048656	Bracket, Horn (N.I.)
30B	2048657	Nut, Horn to Bracket (N.I.)
30C	2031450	Bolt, Horn Bracket to Mount Plate (N.I.)
30D	2031390	Washer, Lock (N.I.)
30E	2031616	Nut (N.I.)
31	2050747	Breaker, Circuit 70 Amp.
31A	2036101	Bolt (N.I.)
31B	2031866	Washer, Lock (N.I.)
31C	2031863	Nut (N.I.)
32	2033377	Relay, Horn
32A	2031427	Bolt (N.I.)
32B	2031390	Washer, Lock (N.I.)
32C	2031615	Nut (N.I.)
33	2068291	Regulator, Voltage (Furnished with Engine)
33A	2031450	Bolt, Regulator to Mount Plate (N.I.)
33B	2031390	Washer, Lock (N.I.)
33C	2031616	Nut (N.I.)
33D	2068249	Mount Plate, Regulator (N.I.)
34	———	Shutdown, Fuel (Furnished with Engine)
35	2068244	Harness, Generator
35A	2068240	Plug Assy. (N.I.)
35B	2068242	Adapter (N.I.)
35C	2068243	Clamp (N.I.)
36	2058369	Wire, Starter to 70 Amp. Breaker
37	2062162	Wire, Terminal Block to Rear Work Light
38	2033414	Cable, Starter to Ground
38A	2032859	Clamp, Battery Cable to Hydraulic Tank (N.I.)
38B	2031471	Bolt, Cable to Boss (N.I.)
38C	2031391	Washer, Lock (N.I.)
39	2061973	Harness, Tail Light
40	2061972	Harness, Tail Light

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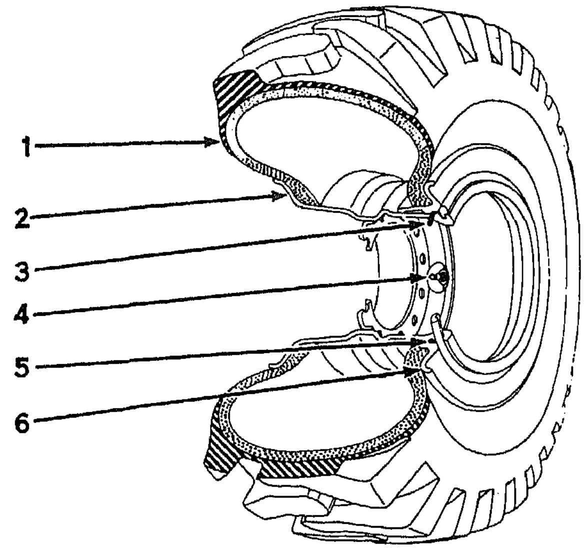


TIRES AND WHEELS

Item	Part No.	Description	No. Req'd.
1	2067830	Tire, Tubeless (23:5 x 25) 19.5 Rim	4
2	2062656	Wheel Assy. (Incl. Items 2A, 3, 5, 6 & 6A)	4
2A	2062655	Rim Base Assy.	4
3	2031148	Ring, Lock	4
4	2030210	Valve Stem Assy.	4
4A	2056824	Cap, Valve	4
4B	2030204	Adapter	4
5	2031147	"O" Ring	4
6	2031146	Band, Bead Seat	4
6A	2030198	Flange	8

REFER TO TM 9-1870-1 FOR INSTRUCTIONS FOR MAINTENANCE OF TIRES.

PART 2

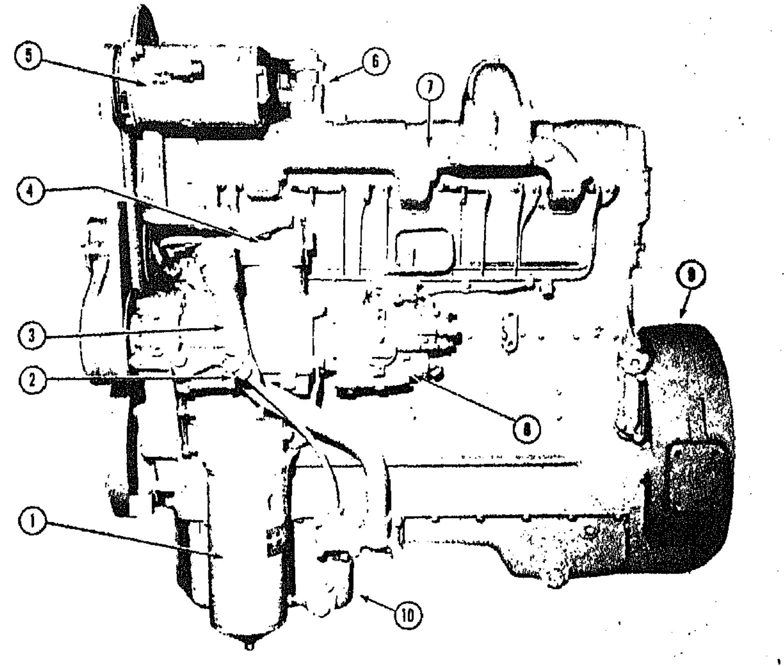
DIESEL ENGINE MODEL C-180

OPERATION AND MAINTENANCE

GENERAL

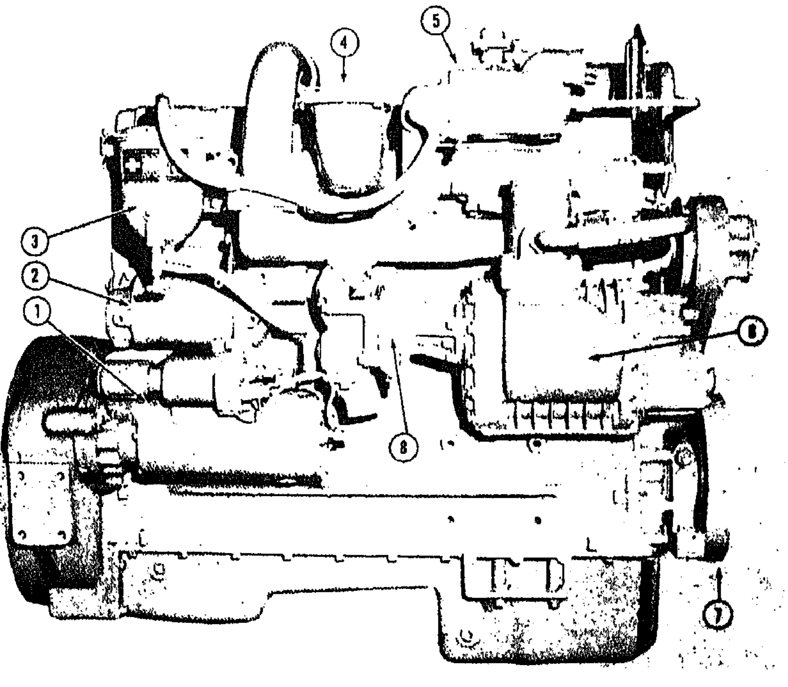
Part 2, Operation and Maintenance is applicable to diesel engine Model C-180-CI as used on Model 3000M Fork Lift. It contains instructions for operators that will enable them to get the best service from their engines. Before operating the engine, become familiar with the procedures described.

The maintenance section is for the men who are responsible for the upkeep and availability of engine on the job. The maintenance program is simple, realistic, easy to control and a profitable one to practice.



1. LUBRICATING OIL FILTER
2. DIPSTICK and TUBE
3. OIL FILLER TUBE
4. AIR COMPRESSOR
5. GENERATOR
6. BREATHER
7. INTAKE AIR MANIFOLD
8. FUEL PUMP
9. FLYWHEEL HOUSING
10. OIL PAN

FIGURE 1
FUEL PUMP SIDE OF ENGINE



1. STARTING MOTOR
2. LUBRICATING OIL COOLER
3. CORROSION RESISTOR
4. EXHAUST MANIFOLD
5. THERMOSTAT HOUSING
6. SUPERCHARGER
7. VIBRATION DAMPER
8. WATER PUMP

FIGURE 2
SUPERCHARGER SIDE OF ENGINE

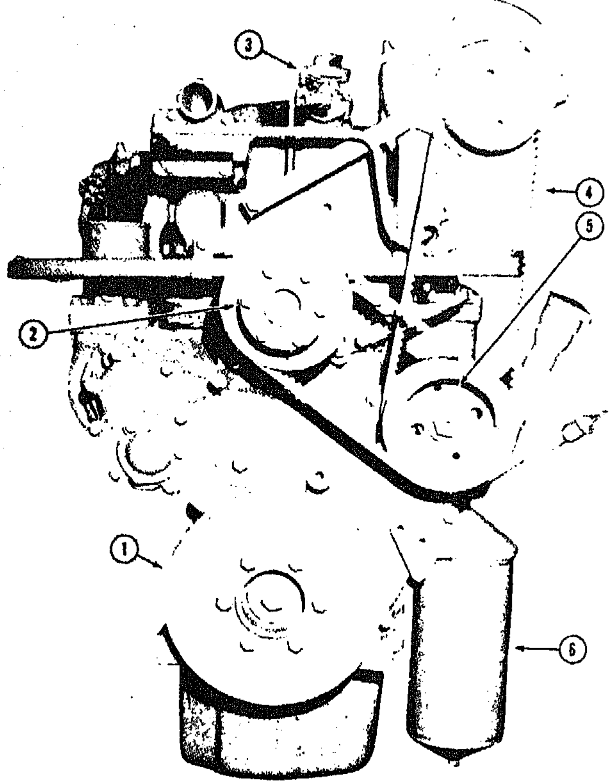


FIGURE 3
FRONT OF ENGINE

1. VIBRATION DAMPER
2. FAN DRIVE PULLEY
3. BREATHER
4. GENERATOR DRIVE
5. ACCESSORY DRIVE
6. LUBRICATING OIL F

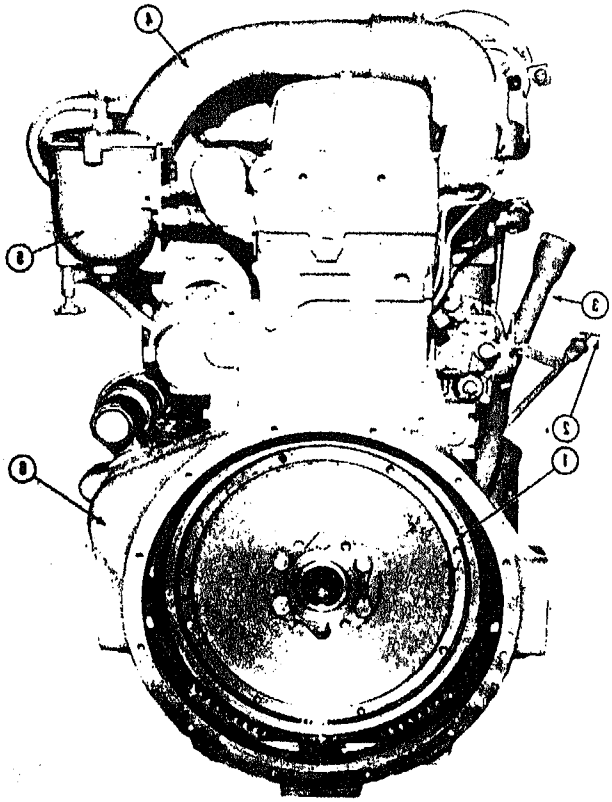


FIGURE 4
BACK OF ENGINE

1. FLYWHEEL
2. DIPSTICK
3. OIL FILLER TUBE
4. AIR INLET CROSSOV
5. CORROSION RESISTO
6. FLYWHEEL HOUSING

Operating Principles

The most satisfactory service can be expected f
Diesel Engine when the operation procedu
based upon a clear understanding of the engine w
principles. Each part of the engine affects the op
of every other working part and of the engine as a
Diesel Engines treated in this manual ar
stroke-cycle, high-speed, full-diesel engines. Hors
ratings and other engine specifications for each mo
tabulated on preceding pages.

The Diesel Engine

Diesel Cycle

Diesel engines differ from other internal combustion engines in a number of ways. Compression ratios are higher than in spark-ignited engines. The charge taken into the combustion chamber through the intake consists of air only — with no fuel mixture. Injectors receive low pressure fuel from the fuel pump and deliver it into the individual combustion chambers at the right time in equal quantity and proper condition to burn. Ignition of fuel is caused by the heat of the compressed air in the combustion chamber.

It is easier to understand the function of engine parts if it is known what happens in the combustion chamber during each of the four piston strokes of the cycle. The four strokes and the order in which they occur are: Intake Stroke, Compression Stroke, Power Stroke and Exhaust Stroke.

Intake Stroke

During the intake stroke, the piston travels downward, the intake valve is open, and the exhaust valve is closed. (Some engines have dual intake and exhaust valves as indicated on preceding introductory pages.)

The downstroke of the piston permits air from outside to enter the cylinder through the open intake valve port. On engines where used, the supercharger or turbocharger increases air pressure in the engine intake manifold and forces it into the cylinder.

The intake charge consists of air only with no fuel mixture.

Compression Stroke

At the end of the intake stroke, the intake valve closes and the piston starts upward on the compression stroke. The exhaust valves remain closed.

At the end of the compression stroke, the air in the combustion chamber has been forced by the piston to occupy a space about one-fifteenth as great in volume as i
pied at the beginning of the stroke. Thus, we s
compression ratio is 15:1, etc.

Compressing the air into a small space causes the te
ture of that air to rise. Near the end of the comp
stroke, the pressure of the air above the piston is a
mately 500 to 600 pounds per square inch and the te
ture of that air is approximately 1000° F [537.8° C]

During the last part of the compression stroke a
early part of the power stroke, a small metered ch
fuel is injected into the combustion chamber.

Almost immediately after the fuel charge is inject
the combustion chamber, the fuel is ignited by t
compressed air and starts to burn.

Power Stroke

During the power stroke, the piston travels downwa
both intake and exhaust valves are closed.

By the time the piston reaches the end of the comp
stroke, the burning fuel causes a further increase
pressure above the piston. As more fuel is add
burns, the gases get hotter and expand more to p
piston downward and add impetus to crankshaft r

Exhaust Stroke

During the exhaust stroke, the intake valves are clos
exhaust valves are open, and the piston is on its up

Burned gases are forced out of the combustion c
through the open exhaust valve ports by the upwar
of the piston.

Proper engine operation depends upon two things
compression for ignition; and second, that fuel be
ed and injected into the cylinder in the proper quan
at the proper time.

'uel System

ie PT fuel system is used on the C-180 Engine. ie identifying letters, "PT," are an abbreviation for "pres- ire-time."

ie operation of the PT Fuel System is based on e principle that the volume of liquid flow is proportionate the fluid pressure, the time allowed to flow and the size passage the liquid flows through. To apply this simple inciple to the PT Fuel System, it is necessary provide:

fuel pump to draw fuel from the supply tank and deliver to individual injectors for each cylinder.

means of controlling the *pressure of the fuel being de-* ered by the fuel pump to the injectors so the individual linders will receive the right amount of fuel for the ower required of the engine.

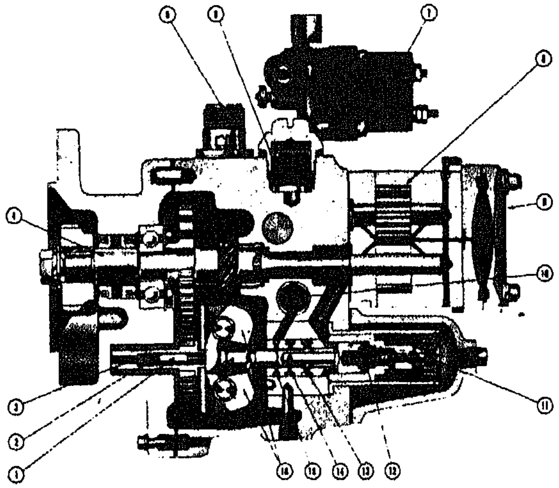
iel passages of the proper size and type so that the fuel ll be distributed to all injectors and cylinders with equal essure under all speed and load conditions.

4. **Injectors to receive low-pressure fuel from the fuel pump and deliver it into the individual combustion chambers at the right time, in equal quantity and proper condition to burn.**

The PT fuel system consists of the fuel pump, supply and drain lines and passages, and the injectors.

Fuel Pump

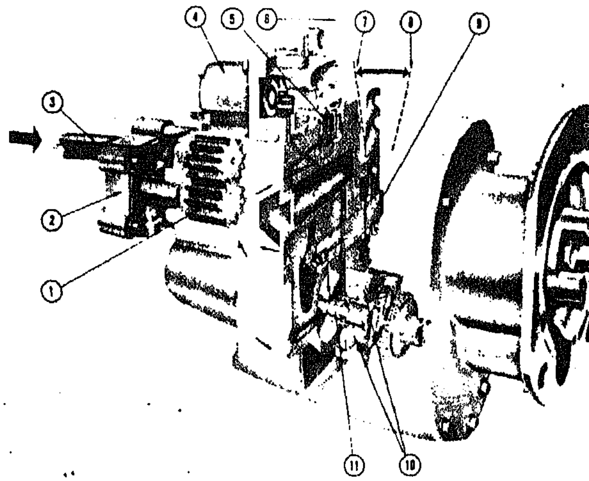
The fuel pump is coupled to the compressor or fuel pump



1. GOVERNOR ASSIST PLUNGER
2. SHIMS
3. GOVERNOR ASSIST SPRING
4. MAIN SHAFT
5. TACHOMETER SHAFT
6. FILTER SCREEN
7. SHUT-DOWN VALVE
8. GEAR PUMP
9. PULSATION DAMPER
10. THROTTLE SHAFT
11. IDLE ADJUSTING SCREW
12. IDLE SPRING
13. GEAR PUMP PRESSURE
14. FUEL MANIFOLD PRESSURE
15. IDLE PRESSURE
16. GOVERNOR WEIGHTS

Fig. 1-2. PT (type G) fuel pump cross section and fuel flow

drive which is driven from the engine gear train. The fuel pump main shaft turns at engine crankshaft speed, and drives the gear pump, governor and tachometer shaft.



1. GEAR PUMP
2. PULSATION DAMPER
3. FROM TANK
4. SHUT-DOWN VALVE
5. FILTER SCREEN
6. TO INJECTORS
7. IDLE
8. FULL
9. THROTTLE SHAFT
10. GOVERNOR WEIGHTS
11. GOVERNOR PLUNGER

FWC5-F\

PT (type G) Fuel Pump

The PT (type G) fuel pump can be identified by the sence of the return line at the top of the fuel pump. pump assembly is made up of three main units.

1. The gear pump which draws fuel from the supply tank forces it through the pump filter screen to the governo
2. The governor which controls the flow of the fuel from gear pump as well as the maximum and idle engine spee
3. The throttle which provides a manual control of fuel f to the injectors under all conditions in the operating ran

The location of fuel pump components is indicated in Fi 1-1 and 1-2 respectively.

Gear Pump And Pulsation Damper

The gear pump is driven by the pump main shaft and c tains a single set of gears to pick up and deliver

ı gear pump contains a steel diaphragm which absorbs ılsations and smoothes fuel flow through the fuel system. om the gear pump, fuel flows through the filter screen

to the governor assembly as own in Fig. 1-2.

ırottle

the throttle provides a means for the perator to manually control engine speed above idle as reıired by varying operating conditions of speed and load.

the PT (type G) fuel pump, fuel flows through the gover-or to the throttle shaft. At idle speed, fuel flows through e idle port in the governor barrel, past the throttle shaft. o operate above idle speed, fuel flows through the main overnor barrel port to the throttling hole in the shaft.

Governors

lling and High-Speed Mechanical Governor: The meıanical governor, sometimes called "automotive governor",

is actuated by a system of springs and weights, nd has two functions. First, the governor maintains sufcient fuel for idling with the throttle control in idle posion; second, it cuts off fuel to the injectors above maxiıum rated rpm. The idle springs in the governor spring ack position the governor plunger so the idle fuel port is pened enough to permit passage of fuel to maintain enne idle speed.

uring operation between idle and maximum speeds, fuel ows through the governor to the injectors in accordance ith engine requirements as controlled by the throttle and mited by the

size of the idle spring plunger counterbore on PT (type G) fuel pumps. When the engine reaches governed speed, the governor weights move the governor plunger, and fuel passages to the injectors are shut off. At the same time another passage opens and dumps the fuel back into the main pump body. In this manner engine speed is controlled and limited by the governor regardless of throttle position. Fuel leaving the governor flows through the shutdown valve, inlet supply lines and on into the injectors.

converter is used to connect the engine with its driven unit. An auxiliary governor may be driven off the torque converter output shaft to exercise control over the engine governor and to limit converter output shaft speed. The engine governor and the converter governor must be adjusted to work together.

The PT torque-converter governor consists of two mechanical variable-speed governors in series — one driven by the engine and the other by the converter. Fig. 1-4.

The engine governor, in addition to giving a variable engine speed, acts as an over-speed and idle-speed governor while the converter-driven governor is controlling the engine. Each governor has its own control lever and speed adjusting screws.

The converter-driven governor works on the same principle as the standard engine governor except it cannot cut off fuel to the idle jet in the engine-driven governor. This insures that, if the converter tailshaft overspeeds, it will not stop the engine.

PT (type G) Variable-Speed Governors

The mechanical variable-speed governor used with the PT (type G) fuel pump: the "Mechanical Va-
Speed" (MVS) governor which is mounted directly o
of, or remotely near, the fuel pump.

Fig's. 1-5

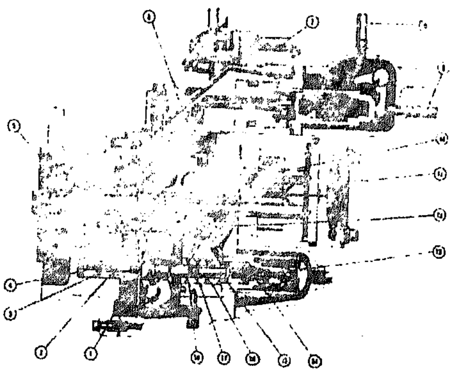


Fig. 1-5. PT (type G) fuel pump with MVS governor

Mechanical Variable-Speed (MVS) Governor

The standard automotive, or maximum-speed, governor has engine speed control only at idle and at the maximum speed condition ranging from maximum full-load speed to the high idle speed. This governor cannot be expected to regulate engine speed below full-load governed speed, and when trying to regulate engine speed by reducing the throttle position, a slight variation in load from the power take-off-driven equipment will cause a widely varying engine speed. Therefore, for all applications in which the engine is driving power take-off equipment, and at the same time the operator is not controlling engine speed by maintaining constant touch with the throttle, it is recommended that MVS governors be used. This governor can also be added to an existing engine or vehicle when necessary, but simple recalibration of the fuel pump is required.

Adjustment for different rpm can be made by means of a lever control or adjusting screw. At full-rated speed, this governor has a speed droop between full-load and no-load of approximately 10%. A cross section of this governor is shown in Fig. 1-5.

As a variable-speed governor, this unit is suited to the varying speed requirements of cranes, shovels, etc., in which the same engine is used for propelling the unit and driving a pump or other fixed-speed machine.

As a constant-speed governor, this unit provides control for pumps, nonparalleled generators and other applications where close regulation (variation between no-load and full-load speeds) is not required.

In a limited number of cases, the engine rpm required for power take-off operation might be higher than the normal full-load governed rpm for that particular engine. This could occur, for instance, when the engine is derated in speed for an economy rating in over-the-road operation. For operations of this type, Cummins Engine Company must be consulted for approval to operate the engine at the higher rpm. In a case of this type, the MVS governor low-speed position would be for full-load governed rpm while the maximum speed position would be set for the PTO operating speed. Also, the automotive governor within the fuel pump would have to be set at the highest required operating speed.

The MVS governor assembly mounts atop the fuel pump, and the fuel solenoid is mounted to the governor housing. See Fig. 1-5. The governor also may be remote mounted.

Fuel from the fuel pump body enters the governor housing and flows to the governor barrel and plunger. Fuel flows past plunger to the shut-down valve and on into the injectors according to governor lever position, as determined by the operator.

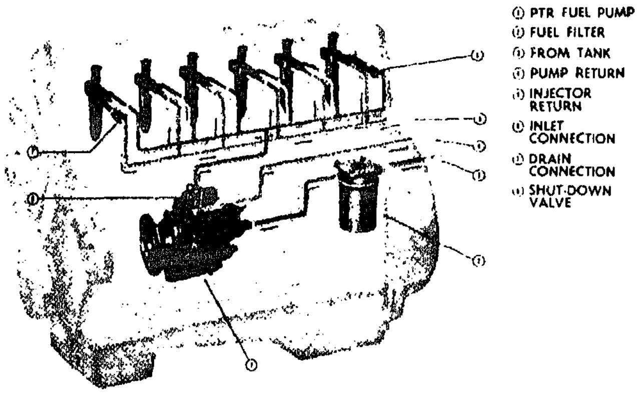
The variable-speed governor cannot produce engine speeds in excess of the automotive governor setting. The governor can produce idle speeds below the automotive pump idle speed setting, but should not be adjusted below the automotive fuel pump speed setting when operating as a combination automotive and variable-speed governor.

Injectors

The injector provides a means of introducing fuel into each combustion chamber. It combines the acts of metering, timing, and injection.

Fuel is supplied to and drained from flanged injectors through external fuel lines and connections as shown in Fig. 1-9. Fuel circulates through the injector at all times except during a short period following injection into the cylinder. From the inlet connection, fuel flows down the inlet passage of the injector, around the injector plunger between the body and cup, and up the drain passage to the drain connections and lines where it returns to the supply tank.

As the plunger rises, the metering orifice is uncovered and part of the fuel is metered into the cup. At the same time, the rest of the fuel flows out of the drain orifice. The amount of fuel passing through the metering orifice and into the cup is controlled by fuel pressure.



Injectors contain an adjustable orifice or selected i
diameter orifice plug in the inlet passage which regu
fuel flow into the injector.

Fuel Lines, Connections And Valves

Supply And Drain Lines

Fuel is supplied through a single tube to the fuel s
manifold as shown in Fig. 1-9. The drain manifold re
fuel, that is not injected, to the supply tank through a
line located at the rear of the engine.

Connections

The fuel supply and drain manifolds are connect
flanged injectors with fuel connections. The inlet co
tion contains a fine mesh screen, which acts as a
filter before fuel enters the combustion chamber.

Shut-Down Valve

Either a manual or an electric shut-down valve is us
Cummins fuel pumps.

With a manual valve, the control lever must be fully c
wise or open to permit fuel flow through the valve.

With the electric valve, the manual control knob mu
fully counterclockwise to permit the solenoid to ope
valve when the "switch key" is turned on. For emer
operation in case of electrical failure, turn manual
clockwise to permit fuel to flow through the valve.

Lubricating System

The working parts of C-180-CI Diesel Engines are pressure lubricated. The pressure is supplied by a gear-type lubricating pump located below the crankshaft and driven by an idler gear off the crankshaft gear. Oil is held in the sump of the oil pan, and is drawn from this sump by the lubricating oil pump. It is delivered to all working parts of the engine through lubricating oil lines and the oil header, the latter being drilled the full length of the block.

Various drillings through the block, cylinder head, crankshaft and rocker levers complete the oil circulating passages.

Lubricating oil is forced through the crankshaft to lubricate main and connecting rod bearings. In some engines, rifle drillings carry oil from the crankshaft through the connecting rods to lubricate the piston pins and bushings. Lubricating oil pressure is controlled by a regulator in the oil filter head or in a separate housing on the engine block.

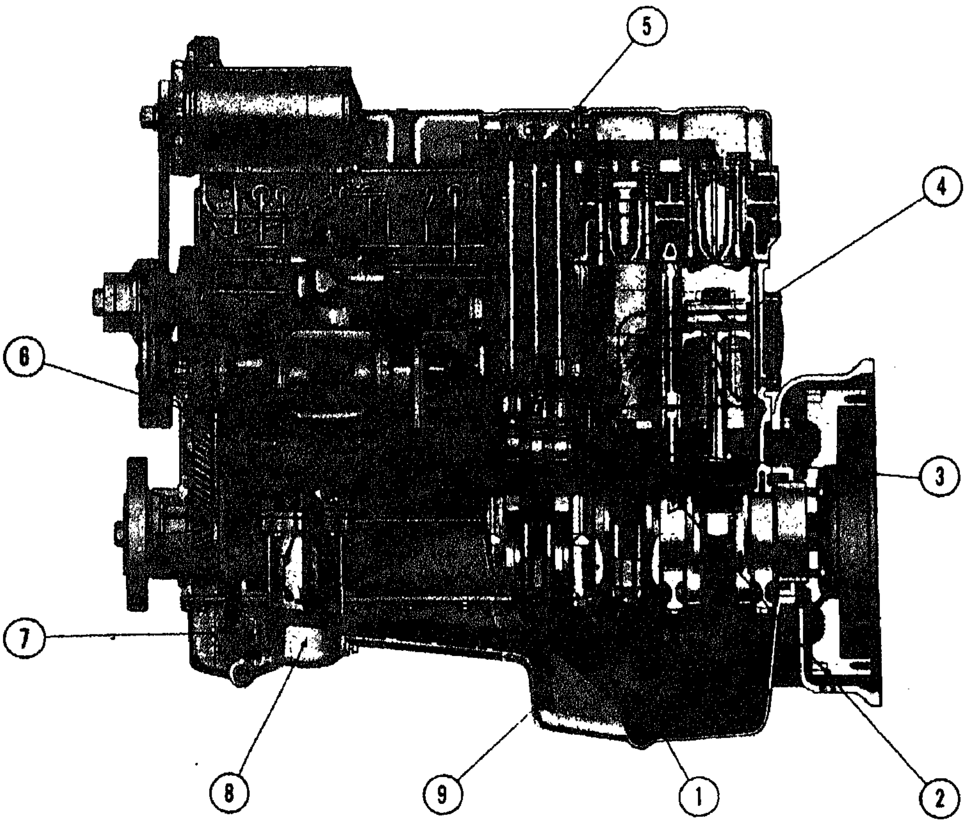
Filters and screens are provided throughout the lubricating system for proper cleaning of lubricating oil.

The air compressor, of the C-180-CI engines receive pressure lubrication from the engine oil supply.

The injector plunger in the injector and working parts in the fuel pump are lubricated by fuel oil. The fuel oil used for lubrication of the injector plunger is returned to the fuel tank through drain lines.

The schematic diagram, Fig. 1-14, shows direction of oil flow and the various units provided to clean and cool hot oil and maintain a constant pressure in the header at governed engine rpm.

A by-pass valve is provided in the oil filter as insurance against interruption of oil flow by a dirty or clogged filter element.



(1) INLET TO PUMP
(2) TO MAIN AND ROD BEARINGS
(3) TO CAMSHAFT
(4) OIL COOLER
(5) ROCKER SHAFT AND LEVERS
(6) OIL GALLERY
(7) LUBRICATING OIL PUMP
(8) OIL FILTER
(9) PRESSURE-RELIEVED OIL TO SUMP

Fig. 1-14. Lubricating oil flow

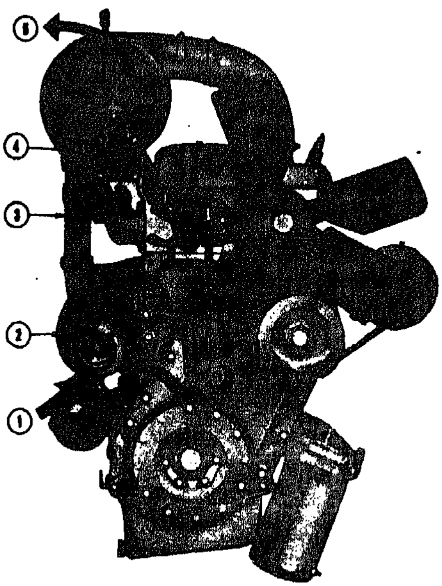
LWC10

Cooling System

Water is circulated by a centrifugal-type water pump mounted on the exhaust side of the engine and driven by a coupling from rear of supercharger. Fig. 1-15.

The water circulates around the wet-type cylinder liners, through cylinder head and around injector sleeves. The injector sleeves in which the injectors are mounted are copper for fast dissipation of heat. The water connection houses a single thermostat to control engine operating temperature.

The engine coolant is cooled by a radiator



① FROM RADIATOR

② WATER PUMP

③ BY-PASS

④ THERMOSTAT

⑤ TO RADIATOR

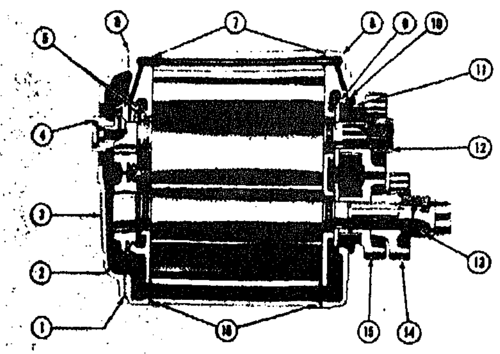
Fig. 1-15. Coolant flow CWC9

Air System

The supercharger forces additional air into the combustion chambers so the engine can burn more fuel and develop more horsepower than if it were naturally aspirated.

Supercharger

A supercharger is a gear-driven air pump which employs rotors to force air into engine cylinders. The supercharger is driven from the engine crankshaft through a gear train turning at about 1.8 times engine speed. Fig. 1-16.



1. COVER GASKET
2. BEARING CAGE SEAL RING
3. END COVER
4. WATER PUMP COUPLING
5. PISTON RING OIL SEALS
6. END PLATE—PUMP END
7. OIL PRESSURE LINE SEAL RINGS
8. END PLATE—GEAR END
9. THRUST WASHER
10. SHIMS
11. BEARING CAGE
12. LOCKNUTS
13. BEARING JOURNAL
14. DRIVE GEAR
15. ROTOR TIMING GEAR
16. OIL DRAIN LINE SEAL RING

Fig. 1-16. Cutaway view of supercharger N21004

Air Compressor

The Air Compressor is a single-cylinder unit driven from the engine by integral crankshaft and accessory drive Lubrication is received from the engine lubrication system, with the oil carried by internal drillings The cylinder head is cooled by engine coolant.

Operating Instructions

The operator of the engine assumes the responsibilit engine care while it is being worked. This is an impor job and one that will determine to a large degree extent of profit from the operation. There are comparat ly few rules which the operator must observe to get best service from the C-180 Diesel. However, if an these rules are broken, a penalty is certain to follow. penalty may be in lack of work accomplished becaus lowered engine efficiency or it may be in down time costly repair bills resulting from premature engine fai

General—All Applications

New Engine Break-In

The way a new engine is operated during the first 3000 mi or 100 hours' service can have an important effect on the life of the engine and its parts. Its moving parts are closely fitted for long service, and even though all engines are run on a dynamometer for several hours before they leave the factory, an additional break-in period insures a uniform oil film and wear pattern are established between all mating parts.

During the first 3000 mi or 100 hours' service:

1. Operate at ½ to ¾ throttle. Do not operate at maximum horsepower for more than five minutes at a time.
2. Do not idle the engine for long periods as this will cause cylinder walls to glaze before the piston rings seat properly and result in excessive lubricating oil consumption.
3. Watch the instruments closely. Decrease engine rpm if oil temperature reaches 250° F [121.1° C] or if coolant temperature exceeds 190° F [87.8° C].
4. Operate with a power requirement low enough to allow acceleration to governed speed under any condition.

Pre-Starting Instructions — First Time

The items covered under this heading are those performed when the engine is first put in service or after a long period of storage. These operations provide conditions which add to engine life by preventing metal surfaces from direct contact during the brief period before a lubrication film is completely established.

Prime Fuel System

1. Prime fuel pump before starting engine for first time. Remove plug next to tachometer drive (PT type G pump) and fill with clean fuel oil meeting the specifications on Page 3-3. On all PT fuel pumps, fill gear pump through suc fitting with clean lubricating oil to aid in faster pick-u fuel. If fuel filter is "dry", fill with clean fuel before sta engine.
2. Check fuel tanks. There must be an adequate supply good grade, clean, No. 2 diesel fuel in the tanks. See " Oil Specifications," Page 3-1.
3. If injector and valve adjustments have been disturbe any maintenance work, check to be sure that they been properly adjusted before starting the engine.

Prime Lubricating System

1. Fill crankcase to "L" (Low) mark on dipstick. See 3-2.
2. Remove ¼ in. pipe plug from the oil gallery (1, Fig. on engines from top (2 lubricating oil filter head for paper-element filters.

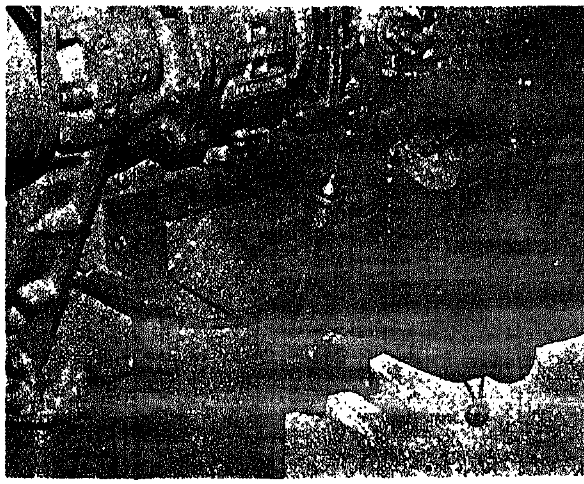


Fig. 2-1. Lubricating oil priming points

onnect a hand or motor-driven priming pump line from ource of clean lubricating oil to oil plug oss.

rime until a 30 psi [2.1093 kg/sq cm] minimum pressure is btained.

rank engine for at least 15 seconds while maintaining ex-ernal oil pressure at a minimum of 15 psi [1.0547 kg/sq m].

emove external oil supply and replace plug in cylinder lock or oil filter head.

ill crankcase to "H" (High) mark on dipstick with oil meet-ng specifications shown on LO No change in oil iscosity or type is needed for new or newly rebuilt engines.

aution: After engine has run a few minutes, it will be ecessary to add lubricating oil to compensate for that bsorbed by filter element(s) and oil cooler.

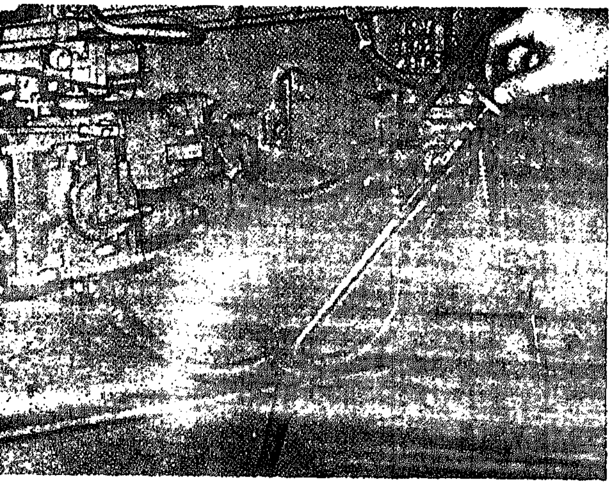
ormal-Daily Checks

heck Oil Level

dipstick oil gauge is located on the side of the engine. he dipstick supplied with the engine has an "H" (High) nd "L" (Low) level mark to indicate lubricating oil supply. he dipstick must be kept with the oil pan, or engine, with hich it was originally supplied.

eep oil level as near the high mark as possible. Fig. 2-2.

aution: Never operate the engine with oil level below e low-level mark, or above the high-level mark.



g. 2-2. Checking engine oil level N21804

Check Air Connections

Check the air connections to the compressor and air equipment, and to the air cleaners.

Check Engine Coolant Supply

1. Remove the radiator or heat exchanger cap and check the engine coolant supply. Add coolant as needed to completely fill the system.
2. Make visual check for leaks.
3. There are several recognized methods of protecting engine cooling systems from rust and corrosion. These methods are described in TB ORD 651.

Check Fuel Supply And Connections

1. Fill fuel tanks with fuel meeting specifications on Page 3-1.
2. Visually check for evidence of external fuel leakage at the fuel connections.
3. Tighten fuel manifold fittings; tighten injector fuel connections to 20/25 ft-lb [2.7660/3.4575 kg m].

Starting The Engine

Starting requires only that clean air and fuel be supplied to the combustion chamber in proper quantities at the correct time.

Normal Starting Procedure

1. Set throttle for idle speed.
2. Disengage driven unit or make sure main disconnect switch is closed.
3. turn switch-key to "ON " position. and press starter button.

Caution: To prevent permanent cranking motor damage, do not crank engine for more than 30 seconds continuously. If engine does not fire within first 30 seconds, wait one to two minutes before recranking.

Spray Nozzle Application Of Starting Fluid

The spray nozzle application is an effective aid in starting the engine when temperatures drop below 50° F [10.0° C].

Caution: This cold-starting fluid should never be used with a preheater glow plug. Serious damage could result.

The spray nozzle assembly consists of a control knob operated from the cab, a flexible cable and cable housing attached to the container (1, Fig. 2-5), which is bracket mounted on the fire-wall. Pulling the knob, in the cab, releases the spray through a small plastic hose (2) into the spray nozzle (3) located in the intake connection or manifold.

Caution: When pulling the knob, do not hold it any longer than 2 seconds at any one time. Serious damage could result from releasing excessive fluid into the intake chambers.

If the engine does not start after the first 2 seconds of spray application, wait 1 or 2 minutes and repeat starting procedure. In extreme cold weather conditions, such as − 25° F [− 31.5° C], if unit will not start with the above instructions, remove starting fluid can and warm to room temperature, and check spray nozzle in the intake connection to be sure orifice holes are free of foreign material. Install can in bracket and connect the spray nozzle; repeat normal starting procedure with use of the spray nozzle.

Direct Application Of Starting Fluid

Caution: Never handle ether near an open flame. Never use it with preheater or flame thrower equipment. Do not breathe the fumes.

1. Pour three tablespoonfuls of ether on a cloth; hold cloth close to air cleaner intake while second man cranks the engine.

Caution: Be sure cloth is outside the air cleaner and can not be drawn into the engine.

2. As an alternate method, spray ether into air cleaner intake while second man cranks the engine. Fig. 2-6.

Caution: Use of too much ether will cause excessive high pressures and detonation.

3. Ether fumes will be drawn into the intake air manifold and the cold engine should start without difficulty.

Other Cold-Starting Aids

Immersion-type water and oil heaters are available for engines used in cold-weather operations.

Water Type

The water heater is installed in place of the water header cover plate on the block. This heater may be rated at 115 V or 230 V, 1000 Watts.

Oil Type

The oil heater is installed in a 1 in. NPTF hole in the oil pan sump. This heater may also be rated at either 115 V or 230 V, 1000 Watts.

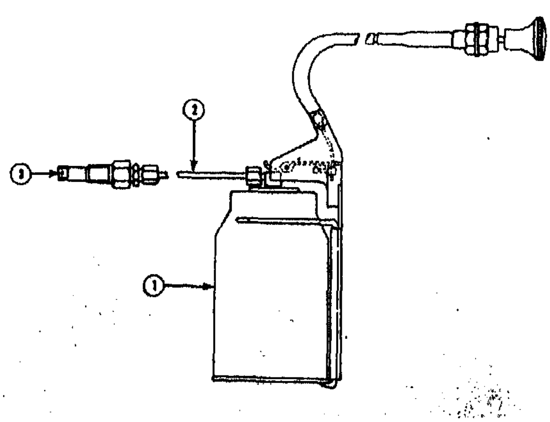
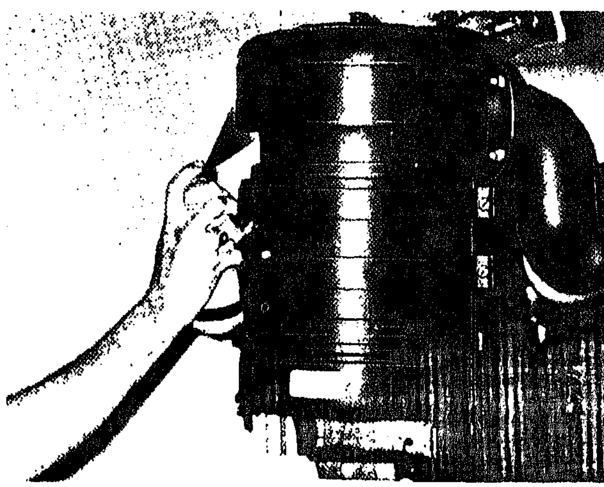


Fig. 2-5 Spray nozzle assembly



Engine Warm-Up

Warm Up Engine Before Applying Load

When the engine is started, it takes a while to get the lubricating oil film re-established between shafts and bearings and between pistons and liners. Allow engine to run at fast idle for 5 minutes or until temperature reaches 140° before engaging load.

Avoid seizing pistons in liners and running dry shafts in dry bearings by bringing the engine up to operating speed gradually as it warms up. Allow the engine to run at 800 to 1000 rpm for some 4 to 5 minutes or preferably until water temperature reaches 140° F [60° C] before engaging the load. During the next 10 to 15 minutes, or until water temperature reaches 160°/165° F [71.1°/73.9° C], operate at partial load at approximately 75% of governed rpm.

Caution: Do not apply more than one-third throttle opening until engine temperature has reached 160° F [71.1° C]. Avoid "gunning" or rapid throttle opening when engine temperature is below normal operating range.

Engine Speeds

Governed Speeds

All engines are equipped with governors to prevent speeds in excess of maximum or predetermined lower speed rating.

The governor has two functions: First, it provides the exact amount of fuel needed for idling when the throttle is in idling position. Second, it over-rides the throttle and shuts off fuel if engine rpm exceeds the maximum rated speed. The model C-180 engine is governed to a full load speed of 2500 rpm and a cruising speed of 2100 rpm.

Instrument Panels

Operate By Instruments

The operator must use the panel board instruments. The instruments show at all times how to get the most satisfa[ctory] service from any engine.

il Temperature Gauge Indicates est Operating Range

e oil temperature gauge normally should read between 0° F [82.2° C] and 225° F [107.2° C] for best lubrication. nder full-load conditions, a temperature of 250/265° F 21.1/129.4° C] for a short period is not to be considered use for alarm.

ution: Any sudden increase in oil temperature that is not used by load increase is a warning of possible mechan- al failure and should be investigated at once.

uring warm-up period, apply load gradually until oil tem- rature reaches 140° F [60° C]. When oil is cold it does t do a good job of lubricating. Continuous operation th oil temperatures much below 140° F [60° C] increases elihood of crankcase dilution and acids in the lubricat- g oil, which quickly accelerate engine wear.

eep Water Temperature Between 55° F [73.9° C] And 195° F [90.5° C]

water temperature of 165° F [73.9° C] to 195° F [90.5° C] the best assurance that cylinder liners are heated to the oper temperature to support good combustion and that orking parts of the engine have expanded evenly to the ost favorable oil clearances. See "Engine Warm-Up".

ngine should be warmed up slowly before applying full ad so pistons will not expand too fast for the cylinder ners. Most cases of piston and liner scoring start with rowing full load on a cold engine.

hen water temperature is too low, the cylinder walls re- rd heating of air during compression and delay ignition. is causes incomplete combustion, excessive exhaust noke and high fuel consumption.

eep thermostats in the engine summer and winter, avoid ng periods of idling, and do whatever else is required to eep water temperatures up to a minimum of 165° F 3.9° C]. If necessary in cold weather, use radiator shut- rs or cover a part of the radiator to prevent overcooling.

Overheating problems require mechanical correction. It may be caused by loose water pump belts, a clogged cooling system or heat exchanger, or insufficient radiator capacity. Report cases of overheating to the maintenance department for correction; a maximum engine coolant temperature of 200° F [93.3° C] should not be exceeded.

Keep An Eye On Oil Pressure Gauge

The oil pressure gauge indicates any drop in lubricating oil supply, or a mechanical malfunction in the lubricating oil system. The operator should note loss of oil pressure and immediately shut down the engine before the bearings are ruined.

Normal Operating Pressures are:

At Idle ....10/30 psi [0.7030/2.1090 kg/sq cm]
At Rated Speed ....40/75 psi [2.8120/5.2825 kg/sq cm]

Note: Individual engines may vary from above normal pressures. Observe and record pressures when engine is new to serve as a guide for indication of progressive engine wear conditions.

Observe Engine Exhaust

The engine exhaust is a good indicator of engine operation and performance. A smoky exhaust may be due to a poor grade of fuel, dirty air cleaner, overfueling or poor mechanical conditions.

If engine exhaust is smoky, corrective action should be taken. Refer to Page 4-1, "Trouble-Shooting Chart".

Maximum Horsepower Requirements

Maximum horsepower is attained only at maximum, or governed, engine rpm. Whenever engine rpm is pulled down by overload, horsepower is lost and continues to be lost as long as the engine continues to lose rpm. When full horsepower is needed, operate the engine near the governor. This rule applies to any kind of application.

When More Power Is Needed, Increase Engine RPM

One rule sums up all rules for proper operation to give the power needed and best performance from the equipment:

Always operate so power requirement will allow the engine to accelerate to, or maintain, governed rpm when advancing to full throttle.

When more torque or power is required, bring engine speed near the governor. This will produce the additional horsepower needed.

High-Altitude Operation

Engines lose horsepower when operated at high altitude because the air is too thin to burn as much fuel as at sea level. This loss is about 3% for each 1000 ft [304.800 m] of altitude above sea level for a naturally aspirated engine. An engine will have a smoky exhaust at high altitude unless a lower gear is used so engine will not demand full-fuel from the fuel system. Smoke wastes fuel, burns valves and exhaust manifolds, and "carbons up" piston rings and injector spray holes. Shift gears as neeled to avoid smoking.

Engine Shut-Down

Let Engine Idle A Few Minutes Before Shutting It Down

It is important to idle an engine 3 to 5 minutes before shutting it down to allow lubricating oil and water to carry heat away from the combustion chamber, bearings, shafts, etc.

Do Not Idle Engine For Excessively Long Periods

Long periods of idling are not good for an engine because operating temperatures drop so low the fuel may not burn completely. This will cause carbon to clog the injector spray holes and piston rings.

If engine coolant temperature becomes too low, raw fuel will wash lubricating oil off cylinder walls and dilute crankcase oil so all moving parts of the engine will suffer from poor lubrication.

If the engine is not being used, shut it down.

Turn Switch Key To "Off" Position To Shut Down Engine

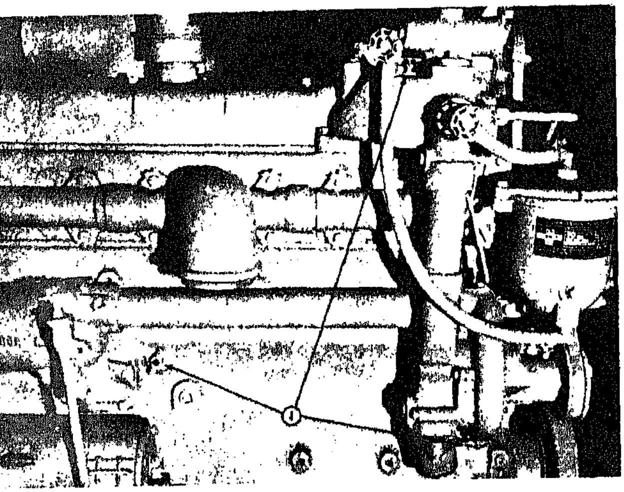
Stop Engine Immediately If Any Parts Fail

Practically all failures give some warning to the oper before the parts fail and ruin the engine. Many engines saved because alert operators heed warning signs (suc drop in oil pressure, unusual noises, etc.) and immedi shut down the engine. A delay of ten seconds after a b ing failure causes a knock may result in a ruined cr shaft or allow a block to be ruined by a broken connec rod.

Never try to make the next trip or another load after engine indicates that something is wrong. It does not

Cold-Weather Protection

1. For cold-weather operation, winterize the cool system as prescribed in TB ORD 651.
2. To completely drain cylinder block and head, open pet or remove drain plug on water pump side of cylinder b at the rear of engine. If an air compressor or other "w cooled" accessory is used, open petcock on unit. Se Fig. 2-8).



ig 2-8. Coolant drain points N20001

Operator's Daily Report

Make A Daily Report Of Engine Operation To Maintenance Department

The engine must be maintained in top mechanical condition if the operator is to get the most satisfaction from its use. Engine adjustments, etc., are the work of organizational maintenance which needs daily running reports from the operator to make necessary adjustments in the time alotted between runs and to make provisions for more extensive maintenance work as the reports indicate the necessity.

Comparison and intelligent interpretation of the daily report along with a practical follow-up action will eliminate practically all operating failures and emergency repairs.

Report to maintenance any of the following conditions:

Low lubricating oil pressure.

Low power.

Abnormal water or oil temperature.

Unusual engine noise.

Excessive smoke.

Trouble Shooting

Trouble shooting is an organized study of the problem a planned method of procedure for investigation and c rection of the difficulty. The chart on the following pa includes some of the problems that an operator may counter during the service life of a 'Diesel Engi

Diesel Engines

The chart does not give all the answers for correction of problems listed, but it is meant to stimulate a train of thought and indicate a work procedure directed toward the source of trouble. To use the trouble-shooting chart, find the complaint at top of chart; then follow down that column until you come to a black dot. Refer to left of dot for the possible cause.

Think Before Acting

Study the problem thoroughly. Ask these questions:

1. What were the warning signs preceding the trouble?
2. What previous repair and maintenance work has been done?
3. Has similar trouble occurred before?
4. If the engine still runs, is it safe to continue running it to make further checks?

Do Easiest Things First

Most troubles are simple and easily corrected; examples are "low-power" complaints caused by loose throttle linkage or dirty fuel filters, "excessive lube oil consumption" caused by leaking gaskets or connections, etc.

Always check the easiest and obvious things first, following this simple rule will save time and trouble.

Double-Check Before Beginning Disassembly Operations

The source of most engine troubles can be traced not to one part alone but to the relationship of one part with another. For instance, excessive fuel consumption may not be due to an incorrectly adjusted fuel pump, but instead to clogged air cleaner or possibly a restricted exhaust pa sage, causing excessive back pressure. Too often, engir are completely disassembled in search of the cause o certain complaint and all evidence is destroyed during c assembly operations. Check again to be sure an easy so tion to the problem has not been overlooked.

Find And Correct Basic Cause Of Trouble

After a mechanical failure has been corrected, be sure locate and correct the cause of the trouble so the sa failure will not be repeated. A complaint of "sticking jector plungers" is corrected by replacing the faulty jectors, but something caused the plungers to stick. T cause may be improper injector adjustment, or more oft water in the fuel.

TROUBLE SHOOTING

DIESEL ENGINES

	CAUSES \ Complaints	Hard Starting or Failure to St	Engine Misses	Excessive Smoking at Idling	Excessive Smoke Under Load	Low Power or Loss of Power	Cannot Reach Governed RPM	Low Air Output	Excessive Fuel Consumption	Poor Deceleration	Erratic Idle Speeds	Engine Dies	Surging at Governed RPM	Excessive Lube Oil Consumpti	Crankcase Sludge	Dilution	Low Lubricating Oil Pressure	Coolant Temperature too Low	Coolant Temperature too High	Lube Oil too Hot	Piston, Liner and Ring Wear	Wear of Bearings and Journal	Worn Valves and Guides	Fuel Knocks	Mechanical Knocks	Gear Train Whine	Excessive Engine Vib
AIR SYSTEM	Restricted Air Intake	●			●	●			●																		
	High Exhaust Back Pressure				●	●			●										●								
	Thin Air In Hot Weather or High Alt.				●	●																					
	Air Leaks Between Cleaner & Engine																				●	●	●				
FUEL SYSTEM	Out of Fuel or Fuel Shut-Off Closed	●										●															
	Poor Quality Fuel	●	●		●	●			●			●												●			
	Air Leaks In Suction Lines	●	●			●					●		●											●			
	Restricted Fuel Lines: Stuck Drain Valve	●	●	●	●	●	●		●	●																	
	External or Internal Fuel Leaks								●							●											
	Plugged Injector Spray Holes	●	●	●	●	●			●		●																
	Broken Fuel Pump Drive Shaft	●										●															
	Scored Gear Pump or Worn Gears	●				●																					
	Loose Injector Inlet or Drain Connection	●														●											
	Wrong Injector Cups			●	●	●			●																		
	Cracked Injector Body or Cup								●							●											
	Mutilated Injector Cup "O" Ring								●							●											
	Throttle Linkage					●	●																				
	Incorrectly Assembled Idle Springs									●	●																
	Governor Weights Assembled Incorrectly											●															
	High-Speed Governor Set Too Low					●	●																				
	Water in Fuel	●	●				●					●															
LUBRICATING SYSTEM	External and Internal Oil Leaks													●		●											
	Dirty Lube Oil Strainer														●							●	●				
	Faulty Cylinder Oil Control			●	●									●		●					●						
	Clogged Oil Drillings																				●	●	●				
	Oil Suction Line Restriction																●				●	●	●				
	Faulty Oil Pressure Regulator																●										
	Crankcase Low or Out of Oil																●		●		●	●	●				
	Wrong Grade Oil for Weather Conditions													●			●										
COOLING SYSTEM	Insufficient Coolant																●		●	●							
	Worn Water Pump																●		●	●							
	Faulty Thermostats														●		●	●	●	●							
	Damaged Water Hose																●		●	●							
	Loose Fan Belts																●		●	●							
	Radiator Shutters Stuck Open														●			●									
	Clogged Water Passages																●		●	●							
	Internal Water Leaks															●											
	Clogged Oil Cooler																●			●							
	Radiator Core Openings Dirty																●		●	●							
	Air in Cooling System																●		●	●							
	Exterior Water Leaks																●		●	●							
	Insufficient Radiator Capacity																●		●	●							
OPERATION AND MAINTENANCE PRACTICES	Dirty Filters and Screens					●									●						●	●	●				
	Long Idle Periods	●	●	●	●	●									●	●											
	Engine Overloaded				●				●								●		●	●	●	●	●	●	●		
	Lube Oil Needs Changing														●						●	●	●				
	Engine Exterior Caked with Dirt																●		●	●							
MECHANICAL ADJUSTMENTS OR REPAIR	Gasket Blow-by or Leakage			●	●	●										●											
	Faulty Vibration Damper																								●		●
	Unbalanced or Loose Flywheel																								●		●
	Valve Leakage	●	●			●																	●				
	Broken or Worn Piston Rings			●	●	●								●							●				●		
	Incorrect Bearing Clearances					●			●								●					●			●	●	
	Excessive Crankshaft End Clearance																					●			●	●	
	Main Bearing Bore Out of Alignment																					●			●		●
	Engine Due for Overhaul	●		●	●	●			●					●			●				●	●	●		●	●	●
	Damaged Main or Rod Bearings																●					●			●		
	Broken Tooth In Gear Train																								●	●	
	Excessive Gear Back Lash																								●	●	
	Misalignment Engine to Driven Unit								●													●				●	●
	Loose Mounting Bolts																								●		●
	Incorrect Valve and Injection Timing	●		●	●	●																	●	●			

Lubricating System Maintenance

Lubricating oil performs four functions in an engine:

1. Reduces friction (heat and wear) by providing a film between bearing surfaces.
2. Scavenges by picking up carbon and other small particles, carrying them to the oil filter where they are taken out of circulation.
3. Cools pistons, liners and bearings and absorbs heat from the engine. This heat is then dissipated by radiation from the pan and by an oil cooler. It is important that air be free to flow around the oil pan.
4. Completes the seal of rings to pistons and cylinder walls.

There are two broad classes of lubrication failures:

1. Those caused by running an engine without, or low on, oil resulting in seizures of pistons or bearings within minutes.
2. Failures due to poor or marginal lubrication, from low oil pressure, dilution, partially clogged oil passages and dirty or clogged lubricating oil filters or improper clearances.

Perform each of the following operations that applies to a particular engine application.

Engine Oil Level

1. Check oil level with dipstick oil gauge located on the engine. For accurate readings, oil level should not be checked for approximately 30 minutes after engine shutdown. Keep dipstick with the oil pan with which it was originally shipped. Keep oil level as near "H" mark as possible.

Caution: Never operate the engine with oil level below the "L" mark or above the "H" mark.

2. Add oil as necessary of the same quality and brand as already in engine

Check For Leaks And Correct

Check for evidence of external oil leakage. Tighten capscrews, fittings, connections or replace gaskets as necessary to correct. Check oil dipstick and filler tube caps. See that they are tightened securely.

Engine Oil Change

The kind of oil used (Mil-L-2104A, Supplement 1, Mil-L-2104B, etc.), the efficiency of the filtering system and condition of the engine must all be considered in determinin[g] when to change oil.

1. Remove pipe plug from bottom of oil pan; drain oil in[to] suitable container. Do not install plug until all oil has drai[n]ed from engine.
2. Install drain plug and torque to 60/70 ft-lb; fill crankcas[e] to high level on dipstick.

Table 5-1: Suggested Initial Oil and Filter Change Period

Filtering Arrangement	Fuel Used Gal [Lit]	Distance Driven Mi. [Km]	Hours Operate[d]
Full-Flow Paper Element Only	800 [3028.000]	7,000 [11,265.100]	250
Full-Flow Paper & By-Pass	1,200 [4542.000]	12,000 [19,311.600]	375

Paper Element Type

1. Remove drain plug from filter case and allow oil to drai[n], Fig. 5-5.
2. Loosen center bolt and remove filter case from filter hea[d]. Some filters use the same case as the bag-type eleme[nt] and should be disassembled in a similar manner.
3. Withdraw filter element. Inspect, then discard.

Note: Inspect for metal particles. If metal is foun[d] a check of connecting rods and main bearing shells shou[ld] be made at once.

4. Remove seal ring from filter head and discard.
5. Clean filter case thoroughly.

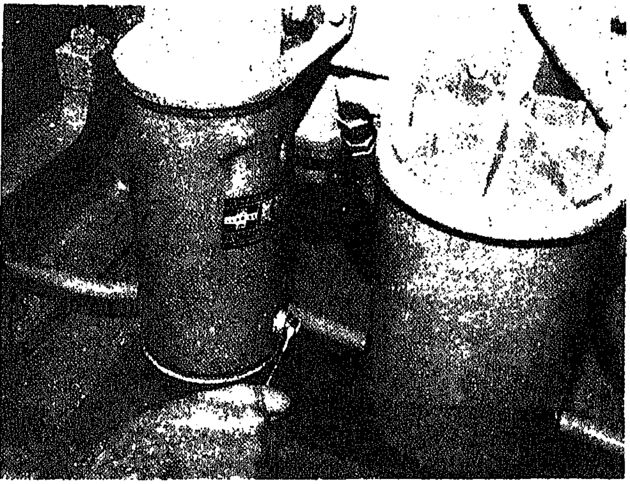


Fig. 5-5. Removing lubricating oil filter drain plug N21980

Check to make sure element end seals are in place and install new element over pilot valve assembly.

Position new seal ring in place; assemble filter case to head and tighten center bolt (if used) to 25/35 ft-lb [3.4575/ 4.8405 kg m].

Check oil level. Run engine and check for leaks.

Recheck engine oil level; add oil as necessary to bring oil level to "H" mark on dipstick.

Note: Always allow oil to drain back into oil pan before checking level.

Change By-Pass Filter Element

Change by-pass filter element on engine so equipped as follows:

Remove drain plug (1, Fig. 5-10) from bottom of housing and drain oil.

Remove clamping ring capscrew (2) and lift off cover.

Unscrew pack hold-down assembly (3); lift out element (4) and hold-down assembly. Discard element.

RECORD OIL PRESSURE

Start the engine and operate at 800 to 1000 rpm until oil temperature gage reads 140°F. Reduce engine speed to idle and record oil pressure. A comparison of pressure at idling speed with previous readings will give indication of progressive wear of lubricating oil pump, bearing shells, shafts, etc. These readings are more accurate and reliable when taken immediately after an oil change.

4. Clean housing and hold-down assembly in solvent.
5. Inspect hold-down assembly spring (5) and seal (6). Replace if damaged.
6. Inspect drain plug and connections. Replace plug.
7. On the by-pass filter, check orifice plug (7) inside oil outlet connection or standpipe; blow out with air jet to make sure orifice is open and clean.
8. Check filter cover "O" ring (8). Replace if damaged or deteriorated.
9. Install new element in housing.
10. Replace hold-down assembly in filter and tighten down to stop.
11. Position cover "O" ring seal.

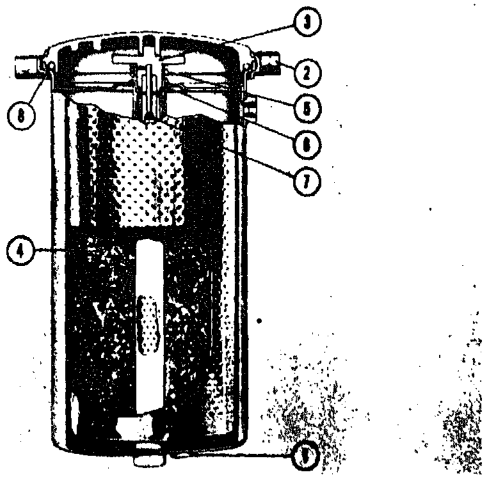


Fig. 5-10. By-pass filter cross section V41906

. Install cover and clamping ring; tighten capscrew until clamping lugs come together.

. Add enough extra oil to crankcase to fill case and element.

. Loosen vent plug in cover and start engine. Close vent plug when oil reaches vent.

Caution: Never use a by-pass filter in place of a full-flow filter.

Lubricate Fan Hub

. Fan hub contains plugged holes (1, Fig. 5-11) for greasing

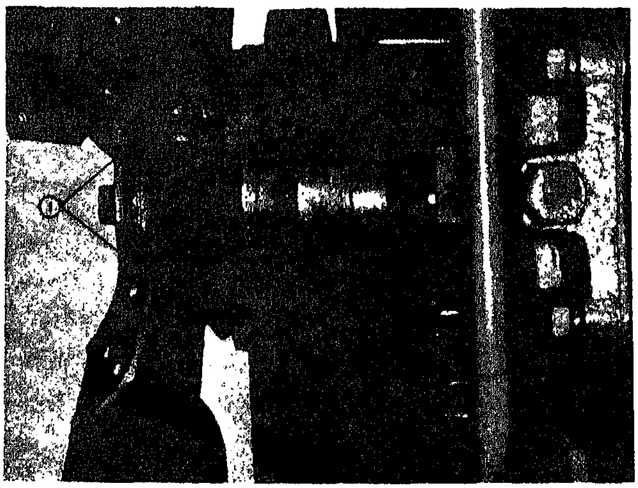


Fig. 5-11. Fan hub lubricating points N21935

purposes, remove plugs, install grease fittings and give one "shot" (approx. 1 tablespoon) of grease at each check.

Caution: After lubricating fan hub, be sure to remove grease fittings and replace plugs. Grease fittings would allow grease to be thrown out, due to rotative speed.

3. Completely disassemble, clean and inspect water pump and fan hub at each third Check.
4. If fan hub has no provisions for greasing, disassemble, clean and inspect at each second check.
5. Pack bearings and fill fan hub bearing cavities 1/2 to 2/3 full of multi-purpose industrial grease meeting specifications.

Fuel System Maintenance

Fuel should always be strained or filtered before being put into the supply tank of an engine. This will lengthen the life of the engine fuel filter and reduce the chances of dirt getting into the fuel pump.

Fuel filter elements are designed to trap dirt and sediment that has entered the fuel system. A filter that has been allowed to become dirty and clogged from overuse will be more of a handicap than help in an engine. It will allow damaging sediment and dirt to circulate through the fuel system and will restrict the flow of fuel, thereby reducing horsepower output.

Excessive amounts of water in the fuel will cause rusting and corrosion in the injectors as well as in fuel pump shafts, bearings and other parts. In some sections it is difficult to purchase fuel that does not contain some water.

Normal condensation, either in the storage tank or in the fuel tank, increases water content. This water, of course, must be filtered out or drained off before it gets into the fuel pump. The life of a fuel pump and injectors can be considerably extended if the operator takes the precaution of draining about a cup of fuel from the lowest point in the fuel system before starting the engine each day.

Drain plugs are located in the bottom of some fuel filter cases, and in the sump of the fuel supply tank. More condensation of water vapor occurs in a partially filled fuel tank than in a full one. Therefore, fuel supply tanks should be kept as nearly full as possible. Warm returning fuel from the injectors heats the fuel in the supply tank. If the fuel level is low in cold weather the upper portion of the tank not being heated by returning fuel tends to increase condensation. In warm weather both the supply tank and fuel are warm. At night, however, the cool air lowers the temperature of the tank much more rapidly than the temperature of the fuel. Again this tends to increase condensation.

In cold weather, water that accumulates in the fuel system will sometimes freeze and block the supply of fuel. This condition can be prevented by adding 1 qt [0.9463 lit] of denatured alcohol to each 50 gal [41.6335 U.K. gal or 189.-2500 lit] of fuel oil. This not only prevents the water from freezing but allows it to go into solution with the alcohol and fuel oil so it can pass through the fuel system and be "burned" without doing any damage.

Fill Fuel Tank(s) (Daily-8 hr)

Always filter or strain the fuel before or while putting it in the tank(s). See "Fuel Oil Specifications", Page 3-3.

Check Leaks And Correct (Daily-8 hr)

1. Check for evidence of fuel leakage.

a. Check fuel pump and filter.

b. Check fuel supply line and connections at fuel tank, fu filter and fuel pump.

c. Check fuel inlet tube and connections at fuel pump shu down valve.

d. Check all fuel supply and drain lines, connections and fi tings on cylinder heads.

e. Check fuel lines and tubing between engine and fu tank(s).

2. If there are indications of air leaks on suction side of fu pump, check for air leaks by placing a sight gauge in th line between fuel filter and pump. Bubbles over ½ i [12.7000 mm] long or "milky" appearance indicates an a leak. Find and correct. See (3, Fig. 5-12).

Drain Sediment From Filter (Daily-8 hr)

1. Loosen the drain cock, if used, at the bottom of the fu filter case and drain out any accumulated water and sec ment. Tighten the drain cock.

2. Unscrew throw-away type elements without drain coc dump water and sediment. Fill element with clean fuel ar reinstall to head.

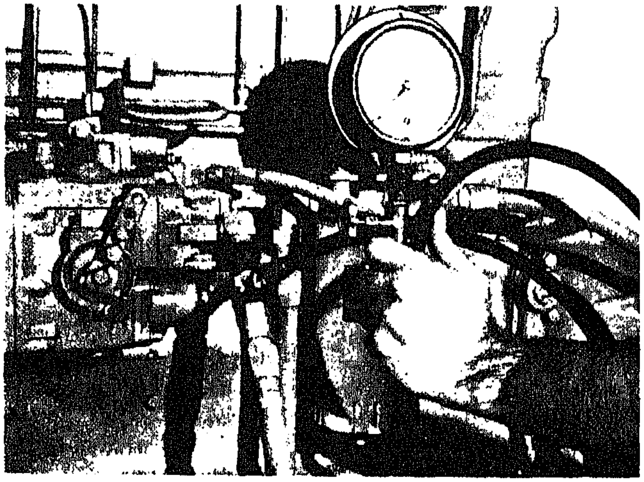


Fig. 5-12. Checking fuel filter restriction N21910

Clean Fuel Tank Breather and Drain Sediment from Tank

1. Clean tank breather in cleaning solvent and dry with compressed air.

2. Loosen fuel tank drain cock or plug and drain approximately 1 cup of fuel. Close cock or install plug.

Change Fuel Filter Element

Normally the fuel filter element is changed monthly or at 200 hours; however, contaminated fuel may require more frequent changes. The following paragraph describes the method of determining fuel filter element change period by measurement of fuel restriction.

Check Fuel Restriction

To check restriction, connect ST-434 Vacuum Gauge (1, Fig. 5-12) to the fuel pump, using the special adapter (2) furnished. If restriction reads 8 to 8.5 inches vacuum while the engine is running at full speed and load, change element or remedy other sources of restriction. When restriction becomes as great as 10 or 11 inches vacuum, the engine will lose power.

Replaceable Element Filter

1. Remove drain plug from bottom of filter case and drain contents.
2. Loosen nut at top of fuel filter. Take out dirty element, clean filter case and install a new element. Fig. 5-14.
3. Install a new gasket in filter head and assemble case and element. Tighten center bolt to 20/25 ft-lb [2.7660/3.4575 kg m] with a torque wrench. Fill filter case with clean fuel to aid in faster pick-up of fuel.
4. Check fittings in filter head for leaks. Fittings should be tightened to 30/40 ft-lb [4.1490/5.5320 kg m].

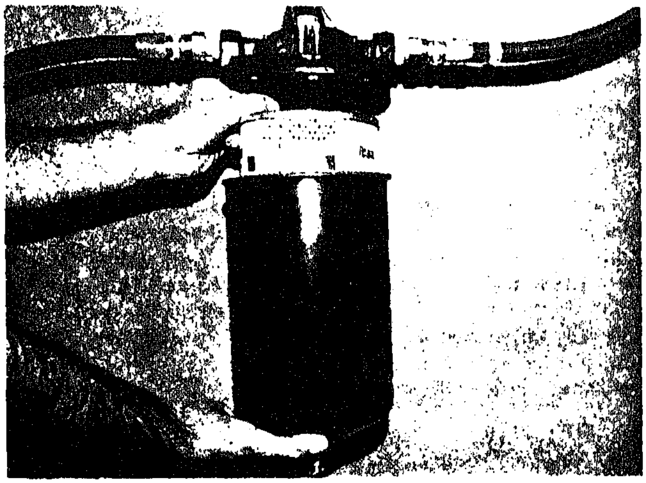


Fig. 5-14. Installing replaceable element fuel filter V11910

(Not used.)

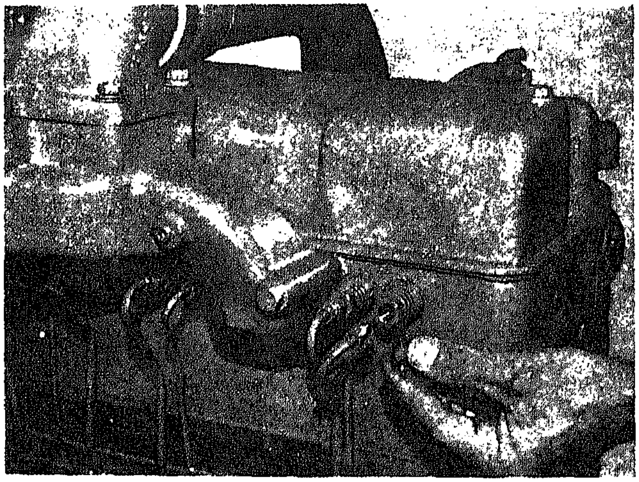


Fig. 5-17. Removing injector inlet screens N21920

LEAN FUEL PUMP SCREEN AND MAGNET (Semi-nnual/500 hr)

emove and clean fuel pump screen and agnet semi-annually or every 500 hours f operation as described in Part 3, nit 502.

Clean And Calibrate Injectors (Annual/1000 Hr)

Clean and calibrate injectors regularly to prevent restriction f fuel delivery to combustion chambers.

o clean and calibrate injectors, refer to Part 3, Unit 600.

Clean Injector Inlet Screens (Semi-annual/500 hr)

Each fuel inlet connection has a fine mesh screen at the arge end. This screen is the last protection against dirt ntering the injector.

o clean: Remove the strainer screen. Fig. 5-17. Wash in olvent and dry with compressed air; reassemble as re-noved.

NOTE: In event contaminated fuel is encountered, injector inlet screens should be cleaned immediately.

Adjust Injectors And Valves (Annual/1000 hr)

t is essential that injectors and valves be in correct adjust-nent at all times for the engine to operate properly. One controls engine breathing; the other controls fuel delivery o the cylinders.

Final adjust-nent must be made when the engine is at operating tem-perature. Injectors must always be adjusted before valves. The procedure is as follows:

Timing Mark Alignment

f used, pull compression release lever back and block in open position to lift all intake valves. This allows the crankshaft to be rotated without working against compression.

2. Bar engine in direction of rotation until No. 1 VS mark appears. See Fig. 5-18 for location of valve set marks. In this position, both intake and exhaust valves must be closed for cylinder No. 1; if not, advance crankshaft one revolution.

3. Adjust injector plunger, then crossheads and valves of first cylinder as explained in succeeding paragraphs. Turn crankshaft in direction of rotation to the next VS mark corresponding to firing order of the engine and the corresponding cylinder will be ready for adjustment.

4. Firing order is as follows:

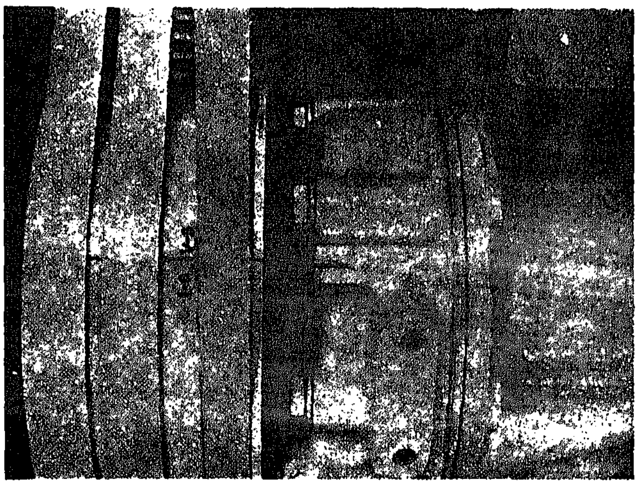


Fig. 5-18. Valve set marks N21459

Table 5-2: Engine Firing Order	
No. of Cylinders	**Left-hand Rotation**
6	1-4-2-6-3-5

Note: Number one cylinder is at the gear case end of the engine.

5. Continue turning crankshaft in direction of rotation and making adjustments until all injectors and valves have been correctly adjusted.

   Note: Two complete revolutions of the crankshaft are needed to set all injector plungers and valves. Injector and valves can be adjusted for only one cylinder at any one "VS" setting.

6. On engines without a compression release, turn each intake valve adjusting screw down one-half turn from adjusted position before turning the crankshaft. Then, adjust injectors and valves on each cylinder in manner described.

Injector Plunger Adjustment

The injector plunger must be adjusted with an inch-pound torque wrench to a definite torque setting.

See Fig. 5-19.

1. Turn adjusting screw down until plunger contacts cup and advance an additional 15 degrees to squeeze oil from cup.
2. Loosen adjusting screw one turn; then, using a torque wrench calibrated in inch-pounds and a screwdriver adapter, tighten the adjusting screw to values shown in Table 5-3 for cold setting and tighten the locknut to 60/70 ft-lb [8.2980/9.6810 kg m]. After all injectors and valves are adjusted and engine has been started and warmed up to 140° F [60° C] oil temperature, reset the injectors.

1154

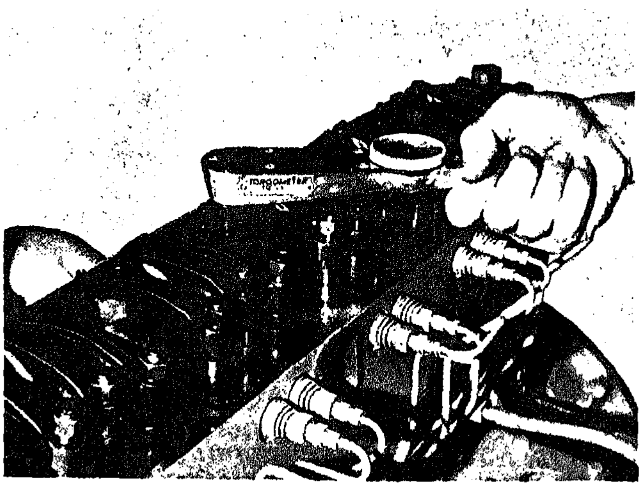


Fig. 5-19. Adjusting injector plunger

Table 5-3: Injector Plunger Adjustment — In.-Lb [kg m]	
Oil Temperature (70° F [21.1° C])	**Oil Temperature (140° F [60° C])**
48 [0.5520]	60 [0.6900]

Crosshead Adjustments

On engines having four-valve heads, it is necessary to a just the crossheads before making valve adjustments.

1. Loosen valve crosshead adjusting screw locknut and bac off screw (4, Fig. 5-20) one turn.
2. Use light finger pressure at rocker lever contact surfac (1) to hold crosshead in contact with valve stem (2) (wit out adjusting screw).
3. Turn down crosshead adjusting screw until it touches valv stem (3).
4. With new crossheads and guides, advance setscrew an a ditional one-third of one hex (20°) to straighten stem on i guide (5) and compensate for slack in threads. With wo crossheads and guides, it may be necessary to advanc screw as much as 30° to straighten stem on its guide.
5. Hold adjusting screw in this position and tighten locknut 25/30 ft-lb [3.4575/4.1490 kg m].
6. Check clearance between crosshead and valve spring r tainer with wire gauge. There must be a minimum of 0.0 in. [0.5080 mm] clearance at this point.

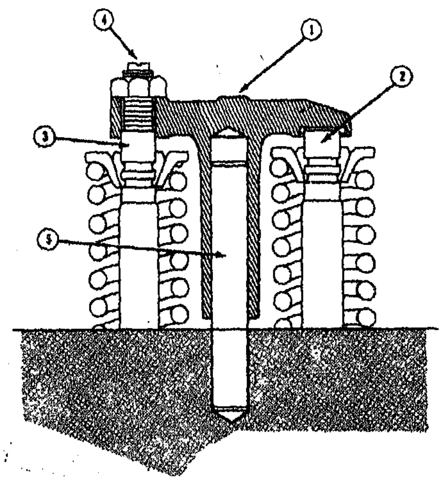


Fig. 5-20. Valve crosshead cross section

Valve Adjustment

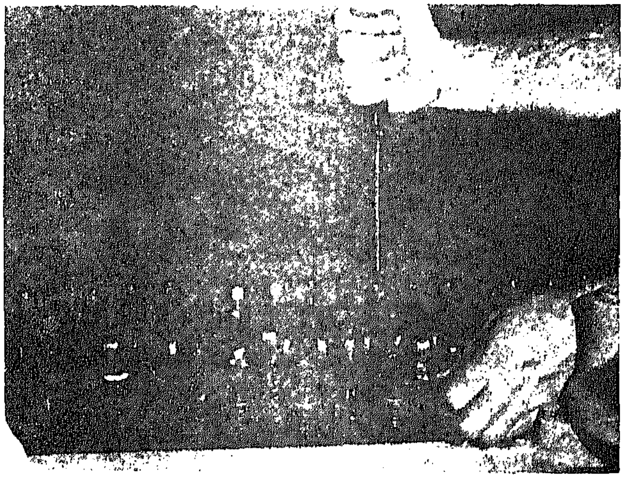
The same engine position used in adjusting injectors is used for setting intake and exhaust valves.

While adjusting valves make sure that the compression release (on those engines so equipped) is in running position.

Loosen locknut and back off the adjusting screw. Insert feeler gauge between rocker lever and top of the valve stem or crosshead. Fig. 5-21. Turn screw down until lever just touches gauge; lock adjusting screw in this position with locknut.

Torque locknut to 60/70 ft-lb [8.2980/9.6810 kg m]. Fig. 5-22.

Always make final valve adjustment after injectors are adjusted and with the engine at operating temperature. Valve clearances are shown in Table 5-4.



5-21. Setting valve clearance N21462

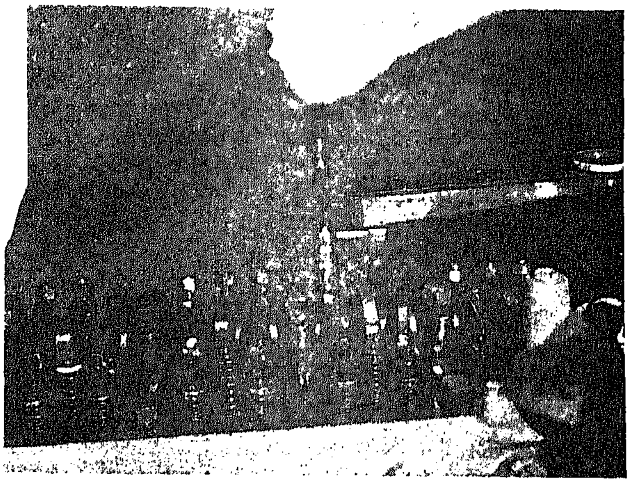


Fig. 5-22. Torquing valve rocker lever locknut with ST-669 N214102

Table 5-4: Valve Clearance — In. [mm]

Intake Valves Oil Temperature 70°F [21.1°C]	Intake Valves Oil Temperature 140°F [60°C]	Exhaust Valves Oil Temperature 70°F [21.1°C]	Exhaust Valves Oil Temperature 140°F [60°C]
0.017 [0.4318]	0.015 [0.3810]	0.027 [0.6858]	0.025 [0.6350]

Check Fuel Manifold Pressure (Annual/1000 hr)

1. Check maximum fuel manifold pressure with ST-435. Fig. 5-23. Remove plug from shut-down valve and connect gauge line. Run engine up until governor "cuts in" and check maximum pressure reached. Compare with previous readings to determine if fuel pressure output is satisfactory. Normally this check is required only if loss of power is suspected.

2. Always make preceding checks on a hot engine and operate engine for a minimum of five minutes between checks to clear system of air.

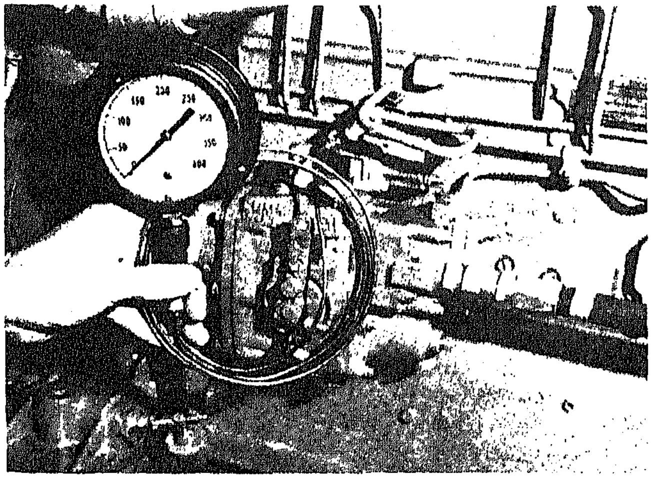


Fig. 5-23. Checking fuel manifold pressure N21473

Cooling System Maintenance

Many operators have been shocked to find water in the crankcase and to learn that it got there through "pin holes" or pitted areas that started on the water side of the cylinder liners.

This "eating away of metal" or corrosion, as it is commonly called, is likely to occur in any heating or cooling system. Corrosion may or may not be associated with iron rust and, as a result, may not show up in the coolant.

Research has shown that there are many causes of corrosion and among the most serious are acid, salt or aeration of the coolant. Acid and salt can be controlled by a properly maintained corrosion resistor as described in the following paragraphs.

Aeration refers to the air bubbles that may be drawn into the radiator core tubes, then into the water pump and engine. The worst effect of aeration is the loss of water pump prime due to an accumulation of air resulting in complete flow stoppage. Entrained air promotes accelerated internal corrosion. Entrained air in the coolant will increase the temperature differential from the combustion gases to the water due to the reduction in heat transfer.

An open (non-baffled) radiator top tank is often the cause of air entering the system. Due to the high velocity of the coolant entering the top tank, the surface becomes very agitated and tends to draw air into the core tubes along with the coolant. It is very difficult on many units to completely fill the cooling system at initial fill, due to the trapping of air in pockets in the engine or other parts of the system. The system should be bled of air or refilled after a short period of operation to purge the coolant of air.

Fill Cooling System (Daily/8 hr)

Keep cooling system completely filled. Check the coolant level daily or at each fuel fill point. Investigate for cause of coolant loss. Recheck the level after engine reaches normal operating temperature. At operating temperature the thermostat is open and water is free to circulate to all parts of the system and fill all air pockets.

Check Leaks And Correct (Daily/8 hr)

Check for evidence of external coolant leakage. Tighten capscrews, hose clamps, fittings and connections or re-

Check And Adjust Belt Tension (Weekly/4

The service life of belts used to drive fans, water p
and generators/alternators can be greatly extende
proper installation, adjustment and maintenance prac
Neglect or improper procedures often lead to proble
cooling or bearing failures, as well as short belt life
lowing are the most important rules to be observed
tend belt life.

Installation

Always shorten distance between pulley centers so belt can be installed without force. Never roll or tighten a belt over the pulley and never pry it on with a tool such as a screwdriver. Both of these methods will damage belts and cause early failure. Diagonal cuts on a failed belt indicate that the failure was caused by rolling a tight belt over the pulley. Cuts from prying a belt in place may be either diagonal or vertical.

Always replace pairs of belts in complete sets to prevent early failure and to provide efficient operation. Belt riding depth should not vary over $\frac{1}{16}$ in. [1.5875 mm] on matched belt sets.

Pulley misalignment must not exceed $\frac{1}{16}$ in. [1.5875 mm] for each ft [30.48 cm] of distance between pulley centers.

Belts should not bottom on the pulley grooves nor should they protrude over $\frac{3}{32}$ in. [2.3811 mm] above top edge of groove.

Do not allow belts to rub any adjacent parts.

Belt Tension

Tighten belts until a reading of 90 to 110 pounds is indicated on ST-968 Belt Tension Gauge. Fig. 5-25.

If belt tension gauge is not available, tighten belts so that the pressure of the index finger will depress belt as shown in Table 5-5. The index finger should be extended straight down from the hand; in this manner, force will be approximately 13 lb [5.8968 kg]. Fig. 5-26.

Readjusting New Belts

All new belts will loosen after running for an hour or more

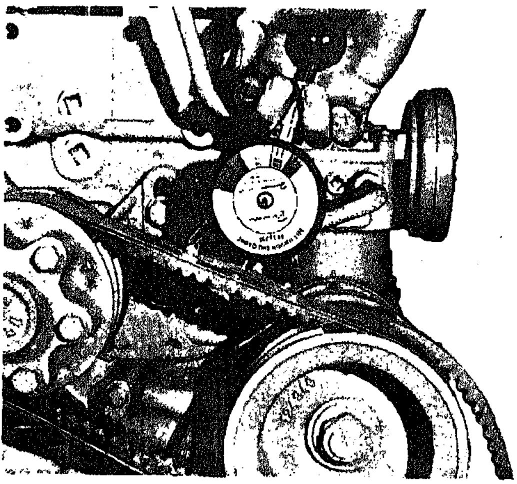


Fig. 5-25. Checking belt tension with ST-968 gauge N21913

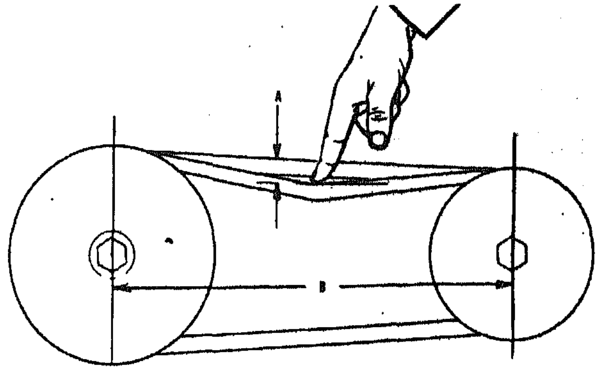


Fig. 5-26. Checking belt tension manually N11471

and must be readjusted. Readjust as described under "Belt Tension".

Table 5-5: Belt Tension — In. [mm]

Belt Width	Deflection Per Ft [30.48 cm] of Span
$\frac{1}{2}$ [12.7000]	$\frac{13}{32}$ [10.3187]
$\frac{11}{16}$ [17.4625]	$\frac{13}{32}$ [10.3187]
$\frac{3}{4}$ [19.0500]	$\frac{7}{16}$ [11.1125]
$\frac{7}{8}$ [22.2250]	$\frac{1}{2}$ [12.7000]
1 [25.4000]	$\frac{9}{16}$ [14.2875]

Belt Care And Maintenance

Belts often slip or squeak because of the glaze that forms due to dirt or steam cleaning.

To clean a belt, wipe it off with approved belt lubricant or hydraulic brake fluid. Cleaning in this manner will eliminate most cases of squeaking.

Do not tighten belt beyond figures given to eliminate belt squeak. Squeak does not necessarily mean belt slippage. Tightening to excess may damage bearings as well as belts.

Check Engine Coolant (Monthly/200 hr)

Periodic tests of engine coolant should be made to insure that the frequency of corrosion resistor servicing or concentration of chromate is adequate to control corrosion for the specific condition of operation.

When using plain water in a cooling system with a corrosion resistor (with chromate-type element) or when treating

with chromate compounds, the concentration of effective inhibitor dissolved in the coolant can be measured by the color comparison method.

Most commercially available antifreezes contain a coloring dye that renders the color comparison method ineffective. When colored antifreezes are present in the coolant, effective control of corrosion can be determined by inspecting the coolant for accumulation of reddish-brown or black, finely granulated dirt. A small amount of corrosion produces significant quantities of these corrosive materials; therefore, if corrosion resistor servicing is adjusted at the first indication of accumulation of these materials, actual corrosion will be limited to a negligible amount.

Examine the sump of corrosion resistor for these "dirt" materials at time of servicing or inspect for them in a small sample of coolant drained from the bottom of the radiator *after allowing coolant to settle.*

Note: Use of chromate compound, added to the coolant without a corrosion resistor, with antifreeze is not recommended.

pH Value Test

1. Separate tubes marked "pH" are furnished in the test kit. Select a tube and fill to mark with coolant to be checked.
2. Add eight drops of the pH Reagent to tube and mix thoroughly.
3. Insert the tube in the comparator hole marked "pH".
4. Compare color of test sample with color standards on either side. Preferred range is 8.3 to 9.5.
5. Wash out test tubes after each test and keep reagent container caps in place.

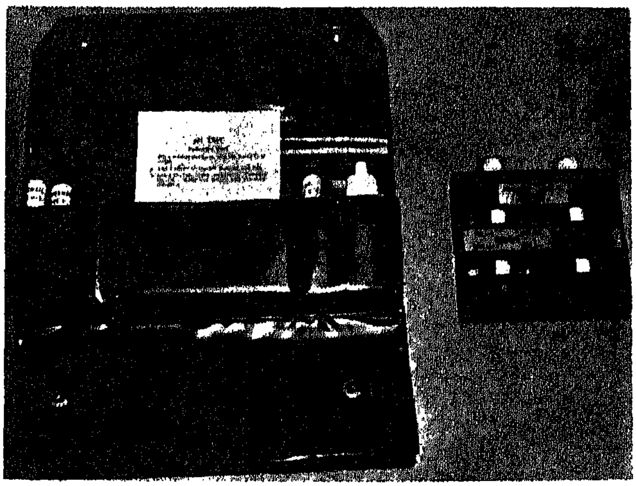


Fig. 5-27. ST-993 Coolant Checking Kit N11946

Chromate Concentration Test

1. Draw sample of coolant and pour into tube marked "chro ate".
2. Insert sample into comparator hole marked "chromate".
3. Compare color of test sample with color standards either side. Preferred range is 100 to 150 grains per gall or 1700 to 2500 parts per million (ppm) as the standar indicate.
4. Wash out test tubes after each test.

Adjusting Coolant To Specifications

If the preceding tests indicate that the coolant is outsi of specifications, make an adjustment immediately to pr vent corrosion.

If the Corrosion Resistor is used, change the el ment, Fig. 5-28, and run engine four to six hours; th check coolant again; in extreme cases it may be necessa to change element a second time. However, the latter co dition may be due to a larger coolant system than the co rosion resistor was designed to treat; note reference resistor label.

Table 5-6: *Comparison Units Chromate Concentration*		
Ounces Per Gallon	**Parts Per Million**	**Grains Per Gallo**
0.16	850	50
0.32	1700	100
0.50	2550	150

If chromate compounds are used, add enough compou to bring concentration to proper level. Normal usage ½ oz [14.7869 cc] chromate for each 1 U.S. gal [0.8327 U. gal or 3.785 lit] of coolant.

Caution: Each time coolant is added to engine, or wh coolant is drained and replaced, chromate concentrati must be rechecked and brought up to proper value adding chromate compound or new corrosion resistor e ment.

Change Corrosion Resistor (Monthly/200 hr)

Change corrosion resistor element at each "C" check u less facilities are available for testing. See "Check Engi Coolant", preceding. Change element when concentrati drops below 100 grains per gallon.

To Change Element:

1. Close shut-off valves on inlet and drain line

lug at bottom of housing.

Remove cover capscrews and cover.

Remove plate securing element; lift element from housing and discard. Remove plate below element.

Lift spring from housing.

Polish plates. If less than half of metal plates can be exposed by polishing, install new plates.

Replace spring and lower plate.

Remove transparent bag from new element; install element in housing. Fig. 5-28.

Replace upper plate, gasket and cover.

Replace drain plug and open shut-off valves in inlet and drain lines.

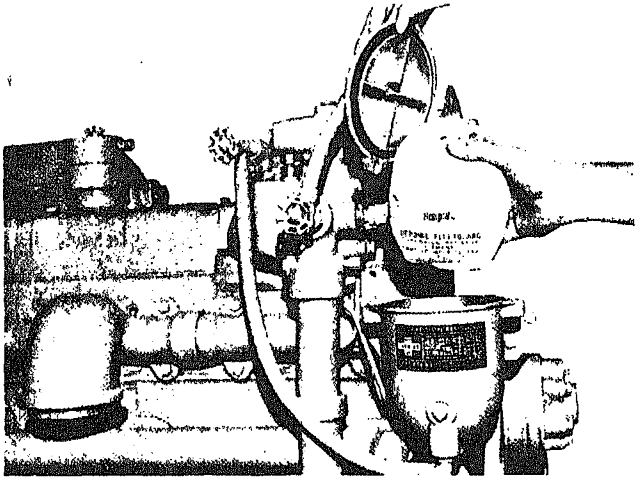


Fig. 5-28. Changing corrosion resistor element N21914

Check Thermal Controls (Semi-annual/500 hr)

Thermostat

The engine is equipped with a 170-180°F thermostat.

The lower value indicates where thermostat starts to open and the higher value where it is fully open. Check stamping on thermostat; install new thermostat with same range as the one removed.

The opening and closing of thermostats can be checked against a thermometer while immersed in water as the water is brought up to temperature by heating. Fig. 5-29.

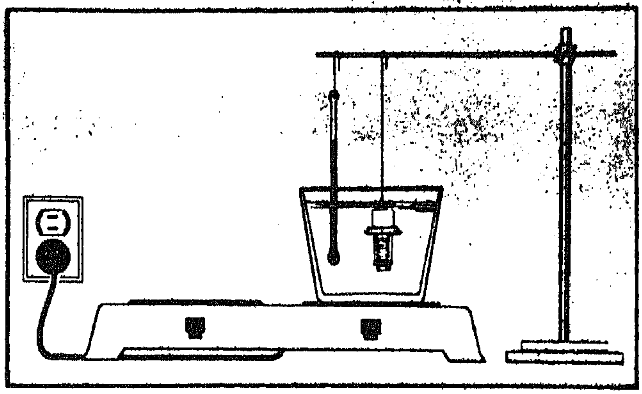


Fig. 5-29. Testing thermostat N10809

Check Fan Hub And Drive Pulley (Semi-annual/ 500 hr)

Check fan hub and drive pulley to be sure that they are mounted securely.

Tighten fan capscrews each check. Check drive pulley for looseness or wobble and, if necessary, remove fan and hub and tighten the shaft nut. Tighten the bracket capscrews.

Clean Cooling System (Spring And Fall)

The cooling system must be clean to do its work prope Scale in the system slows down heat absorption from wa jackets and heat rejection from the radiator. Use cl water which will not clog any of the hundreds of small p sages in the radiator or water passages in the block.

Clean out radiator cores, heater cores, oil cooler and he and block passages which have become clogged with sc and sediment by chemical cleaning, neutralizing and flu ing.

Chemical Cleaning

The best way to insure an efficient cooling system is to p vent formation of rust and scale by using a C rosion Resistor, but if they have collected, the system m be chemically cleaned. Use a good cooling system clea such as sodium bisulphate or oxalic acid followed neutralizer and flushing.

Pressure Flushing

Flush the radiator and block when anti-freeze is added removed, or before installing a Corrosion Resistor or used engine.

When pressure flushing the radiator, open the upper lower hose connections and screw the radiator cap on ti Remove thermostat from housing and flush head and bl with water. Use hose connections on both upper and lo connections to make the operation easier. Attach the flu ing gun nozzle to the lower hose connection and let wa run until the radiator is full. When full, apply air press gradually to avoid damage to the core. Shut off the air allow radiator to refill; then apply air pressure. Repeat til water coming from radiator is clean.

Sediment and dirt settles into pockets in the block as v as the radiator core. Remove thermostat from housing flush block with water. Partially restrict the lower open until the block fills up. Apply air pressure and force wa from the lower opening. Repeat the process until stream water coming from block is clean.

Air System Maintenance

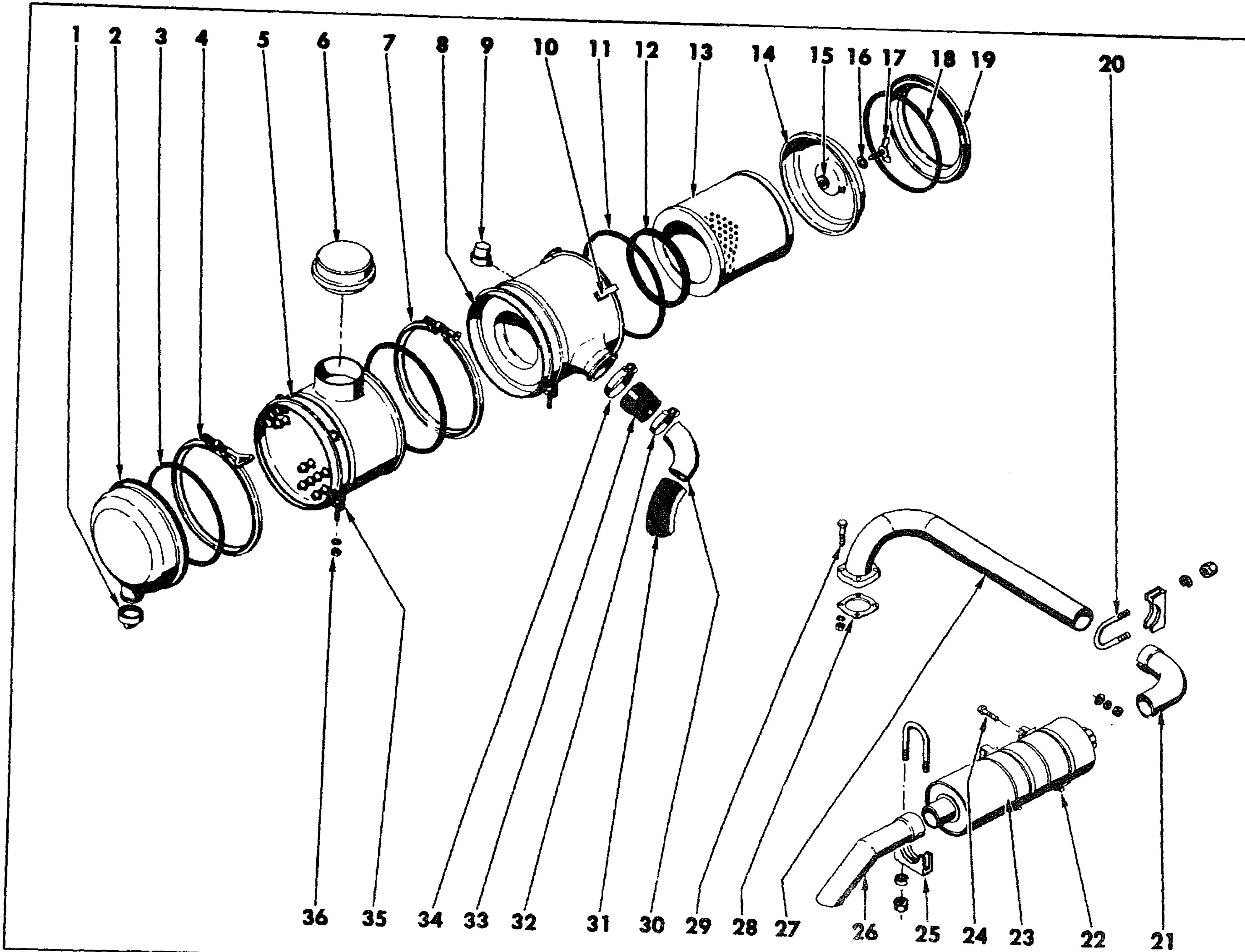
ne diesel engine requires hundreds of gallons of air for very gallon of fuel that it burns. For the engine to operate fficiently, it must breathe freely; the intake and exhaust ystem must not be restricted.

alves, pistons and rings must seal properly against com-ression and combustion pressures.

ne amount of fuel that can be burned and the power de-eloped is as dependent upon air as fuel. If there is too tle air to burn all the fuel, the excess fuel causes a smoky xhaust, high exhaust temperatures and a loss of horse-ower.

Vasted fuel is not the only loss caused by incomplete com-ustion. The excess fuel washes lubricating oil off cylinder alls resulting in seized pistons and bearing failures. Car-oned injector cup spray holes and stuck piston rings are ther troubles which result from insufficient air. Dirty air eaner elements, leaky valves, worn rings, damaged silenc-rs and air piping that is too small or with sharp bends are ommon causes of air restriction. Therefore, it is neces-y to perform air system maintenance regularly as follows.

ote: When engines operate under extremely dusty condi-ons, adjust the maintenance intervals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TP1050

AIR CLEANER AND EXHAUST SYSTEM

Item	Part No.	Description	No. Req'd.
A	2058371	Cleaner Assy., Air (Incl. Items 1 thru 5 & 7 thru 19)	1
1	2057939	Valve, Vacuator	1
2	6951146	Cup Assy.	1
3	6950664	"O" Ring	2
4	2022518	Clamp Assy.	1
5	6950665	Body Assy.	1
6	2005034	Cap, Air Stack (Furnished with Engine)	1
7	6950662	Clamp Assy.	1
8	6950661	Body Assy. (Incl. Items 9 thru 12)	1
9	2065358	Indicator, Restriction	1
10	6950968	Latch	4
11	6951145	Gasket	1
12	6950672	Gasket	1
13	6950541	Element Assy.	1
14	6950659	Cover Assy., Inner (Incl. Item 15)	1
15	6950633	Gasket	1
16	2022515	Gasket	1
17	6950660	Bolt Assy. (Incl. Item 16)	1
18	6950671	Gasket	1
19	6950623	Cover Assy. (Incl. Item 18)	1
20	2043894	Clamp, Muffler	2
21	2046915	Elbow, 90°	1
22	2037093	Clamp, Muffler to Frame	2
23	2030538	Muffler	1
24	2031477	Bolt, Clamp to Frame	4
24A	2032960	Washer, Flat	4
24B	2031391	Washer, Lock	4
24C	2031617	Nut	4
25	2068283	Clamp, Muffler	1
26	2067853	Tube, Exhaust	1
27	2056716	Elbow Assy., Exhaust	1
28	2031969	Gasket, Exhaust (Furnished with Engine)	1
29	2031524	Bolt, Elbow to Engine (Furnished with Engine)	4
29A	2031393	Washer, Lock	4
29B	2031619	Nut	4
30	2056702	Elbow, Air Intake	1
31	2057208	Elbow, Tube to Engine, 45°	1
32	2056715	Clamp, Hose (Furnished with Engine)	3
33	2047618	Reducer, Cleaner to Tube	1
34	2056714	Clamp, Hose (Furnished with Engine)	1
35	2030542	Band, Mounting (Furnished with Engine)	2
36	2031475	Bolt, Band	4
36A	2031391	Washer, Lock	4
36B	2031617	Nut	4

Cartridge-Type Air Cleaner (Semi-annual/500 hr)

The best method to determine when to change any dry-type air cleaner is by use of a filter restriction indicator which clearly indicates when the element is loaded. Fig. 5-34. Other indications are a loss of engine power or excessive smoke in the exhaust gases.

Cartridge changes can be scheduled, but due to wide variations in dust and weather conditions, even in the same location, changing "as required" is usually more economical.

The filter restriction indicator signals when to change cartridges. The flag in the window (1, Fig. 5-34) gradually rises as the cartridge loads with dirt. When locked, the flag will remain up after the engine is shut down. Do not change cartridge until the flag reaches the top and locks in that position. After changing the cartridge, reset the indicator by pushing the re-set button (2). Push button all the way in firmly, then release. If button sticks, repeat pushing slowly.

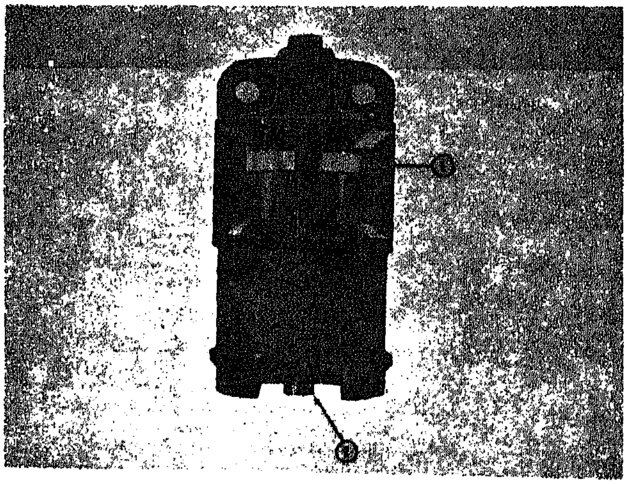


Fig. 5-34. Air inlet restriction gauge

N21023

Check Air And Vapor Line Connections (Monthly/ 200 hr)

Perform At B Check Under Extreme Dusty Conditions. (Weekly/40 hr)

Check all air and vapor lines and conections from compressor, supercharger, cylinder head cover and cylinder head for leaks, breaks, stripped threads, etc.; correct as necessary.

In cold weather, condensed moisture in air tanks and lines

may freeze and make brakes useless.

Drain air tanks to keep all water out of the brake system.

Check Air Piping (Monthly/200 hr)

Perform At B Check Under Extreme Dusty Conditions. (Weekly/40 hr)

Check air intake piping from air cleaner to intake manifold. Check for loose clamps or connections, cracks, punctures, or tears in hose or tubing, collapsed hose, or other damage. Tighten clamps, Fig. 5-36, or replace parts as necessary to insure an airtight air intake system. Make sure that all air goes through the air cleaner.

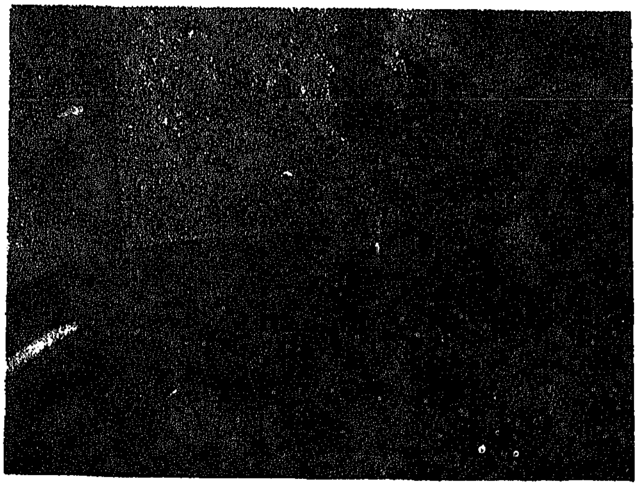


Fig. 5-36. Tightening air inlet tubing clamp N21922

Check For Oil Leaks At Supercharger (Semi-annual/500 hr)

Supercharger

Remove supercharger outlet connection, Fig. 5-43, a visually check ends of the rotors and case for evidence oil leakage from supercharger seals. Rotors will alw show some oil from the vapor tube that is connected to cylinder head cover.

Only the appearance of "wet" oil at ends of the rotors a excessive oil consumption should be cause for chang supercharger seals.
Check supercharger connections for leaks and correc necessary.

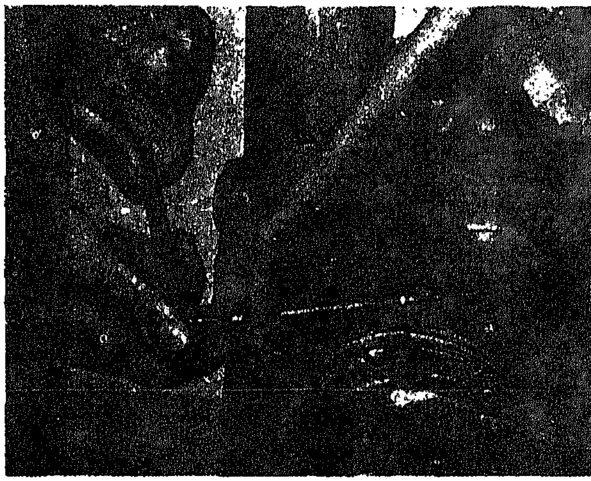


Fig. 5-43. Removing supercharger outlet connection N2

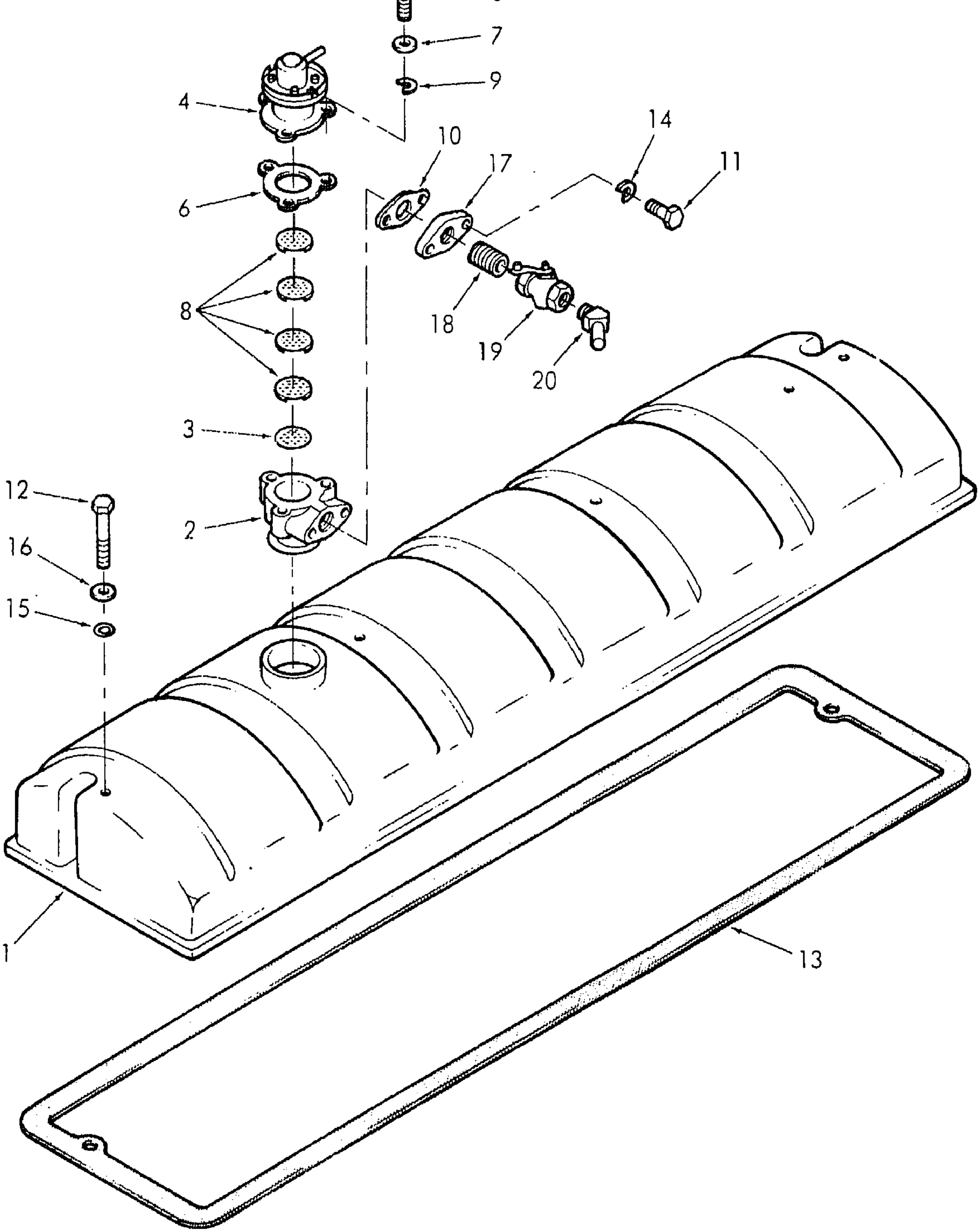


Figure 5-47. Cylinder Head Cover, Crankcase Breather, and Fording Kit.

Tighten Manifold Nuts Or Capscrews (Semi-annual/500 hr)

Check exhaust and intake manifolds mounting hardware for tightness. Fig. 5-45. Correct as required.

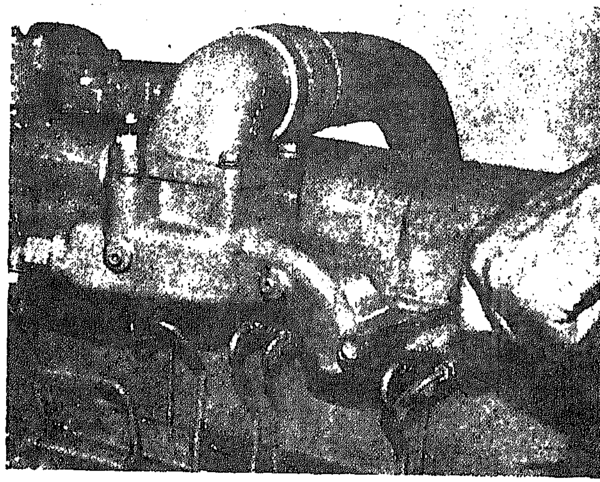


Fig. 5-45. Tightening intake manifold capscrews N21

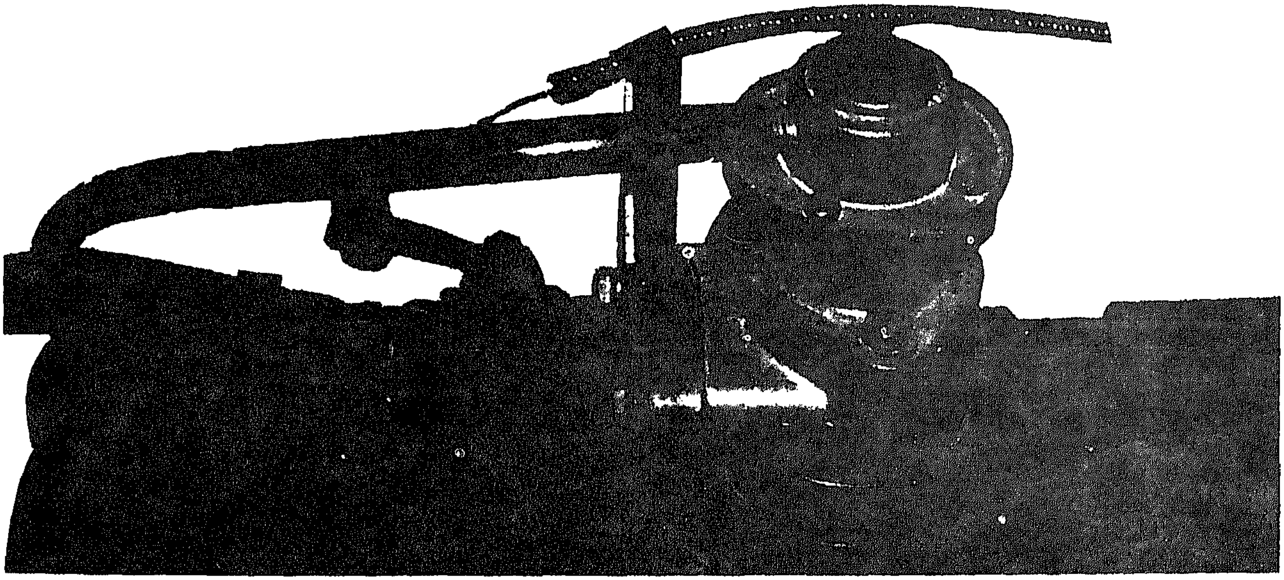
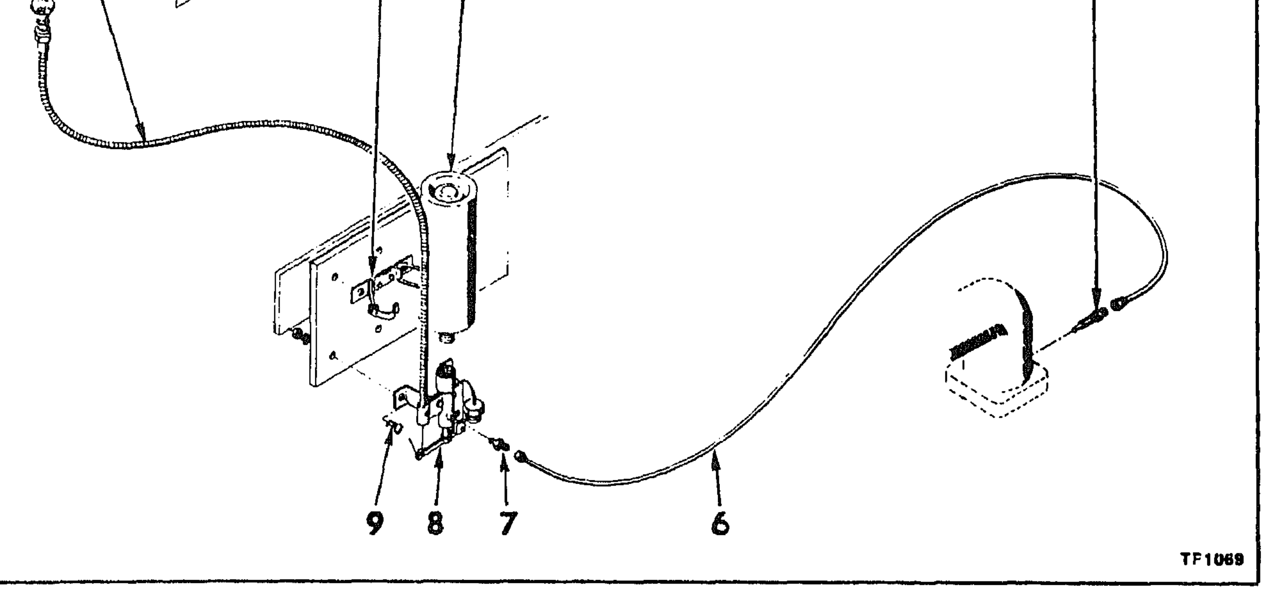


Fig 5-46 Water-fording valve and crankcase breather.

WATER-FORDING VALVE AND CRANKCASE BREATHER (Semi-annual/500 Hr)

Remove screws securing crankcase breather, remove five inner screen plates and clean with fuel oil. Dry thoroughly and reinstall plates and breather. Check insides of hoses for sludge build-up. Remove and clean hoses with fuel oil. Replace cracked or soft hoses.



ETHER STARTING KIT

Part No.	Description	No. Req'd.
2036554	Kit, Ether Starting (Incl. Item 1 thru 8)	1
2036560	Cable & Clamp, Choke	1
2036564	Decal	1
2036561	Clamp, Tank	1
2036555	Cylinder, Disposable Fuel	1
2036558	Fitting (Air Intake)	1

Item	Part No.	Description	No. Req'd.
6	2036556	Tube, Nylon	1
7	2036557	Fitting (Valve)	1
8	2036559	Valve & Bracket	1
9	2036097	Screw, Machine	4
9A	2031866	Washer, Lock	4
9B	2031863	Nut	4

Starting Fluid Applicator

1. Remove starting fluid can; replace if empty.
2. Remove plastic hose from spray nozzle. Clean the hose with compressed air and replace if damaged.
3. Remove spray nozzle from intake connection or manifold and inspect orifice holes. Make sure they are clear; clean with compressed air.

Other Maintenance

Check Operator's Report (Daily/8 hr)'

Check the operator's daily or trip reports, and investigate and correct reported cases of:

Low lubricating oil pressure.

Low power.

Abnormal water or oil temperature.

Unusual engine noises.

Excessive smoke.

Clean Dust From 'Generator And Cranking Motor (Monthly/200 hr)

Dust and dirt, if allowed to accumulate in the generator/alternator and cranking motor, will cause excessive wear of bearings, brushes and commutator.

Remove the cover band and blow out the dust and dirt with compressed air.

TIGHTEN AND INSULATE ELECTRICAL CONNECTIONS

Hard starting is often traceable to loose or corroded battery connections. A loose connection will overwork the generator/alternator and regulator and shorten their lives.

Add distilled water to battery cells to keep tops of plates covered.

Remove corrosion from around terminals; then coat with petroleum jelly.

3. Keep connections clean and tight. Prevent wire and lugs from touching each other or any metal except screw terminals to which they are attached.
4. Replace broken or worn wires and their terminals.
5. Have battery tested periodically. Follow battery manufacturer's instructions for maintenance.

Check Generator and Cranking Motor Brushes And Commutators (Semi-annual/500 hr)

The failure of an alternator/generator or cranking motor may cause unit downtime and nearly always results in expensive replacement.

1. Clean dirty commutators with No. 00 sandpaper; never use emery cloth.
2. Replace worn brushes. If brushes wear rapidly, check for incorrect brush spring tension, Fig. 5-49, or high mica on the commutator. Check output by action of ammeter indicator needle after brush replacement.
3. Shorts and incorrect polarization can be detected at the ammeter. Incorrect polarization is indicated by a minus reading when generator is turned. Take unit to an electric service station for immediate correction.
4. Troubleshoot the cranking motor, Unit 1301, or the generator, Unit 1302, Part 3.

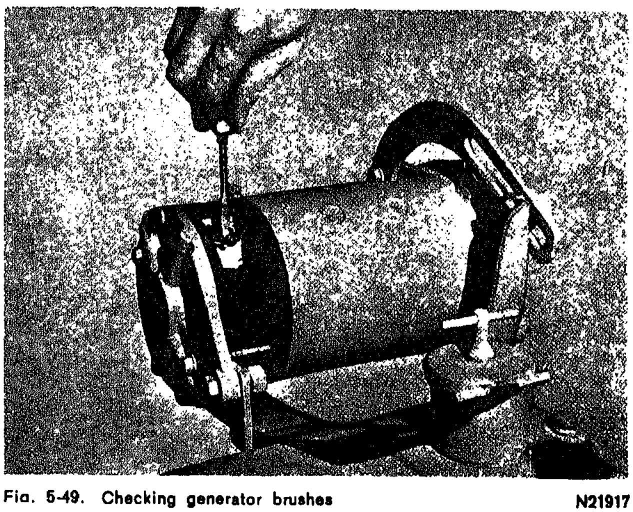


Fig. 5-49. Checking generator brushes N21917

CLEANING THE ENGINE

There are many reasons why the exterior of the engine should be kept clean. Dirt from the outside will find its way into the fuel and lubricating oil filter cases and into the rocker lever assembly when the cover is removed unless dirt is removed first.

Steam is the most satisfactory method of cleaning a dirty engine or piece of equipment. If steam is not available, use mineral spirits or some other solvent to wash down the engine.

All non-waterproof electrical components and wiring will be protected from steam, water jets, and solvents.

Tighten Mounting Bolts And Nuts (Weekly/8 hr)

Mounting bolts will occasionally work loose and cause the supports and brackets to wear rapidly. Tighten all mounting bolts or nuts and replace any broken or lost bolts or capscrews.

Check Engine Blow-By (Semi-annual/500 hr)

Engine blow-by (escape of combustion gases past pistons and liners) is usually caused by worn or stuck piston rings, worn cylinder liners or worn pistons.

Blow-by can be detected by running the engine and observing the gas escape from the lubricating oil filler hole with cap or breather open or removed. There is always some vapor or gas escape at this point due to heated oil and piston movement, but distinct puffs indicate blow-by. Experience and comparison with other units operating at the same speed are needed to make a conclusion as to the extent of blow-by. Normally, excessive blow-by is accompanied by oil consumption.

Direct support personnel will check engines for blow-by under loaded conditions, with special tools, to determine if blow-by is excessive. Fig. 5-50.

Check Crankshaft End Clearance (Semi-annual/500 hr)

The crankshaft of a new or newly rebuilt engine must have end clearance as listed for that model in Table 5-9. A worn engine must not be operated with more than the worn limit end clearance shown in the same table. If engine is

Table 5-9: Crankshaft End Clearance — In. [mm]

New Minimum	New Maximum	Operating Worn Limit
0.004 [0.1016]	0.011 [0.2794]	0.022 [0.5588]

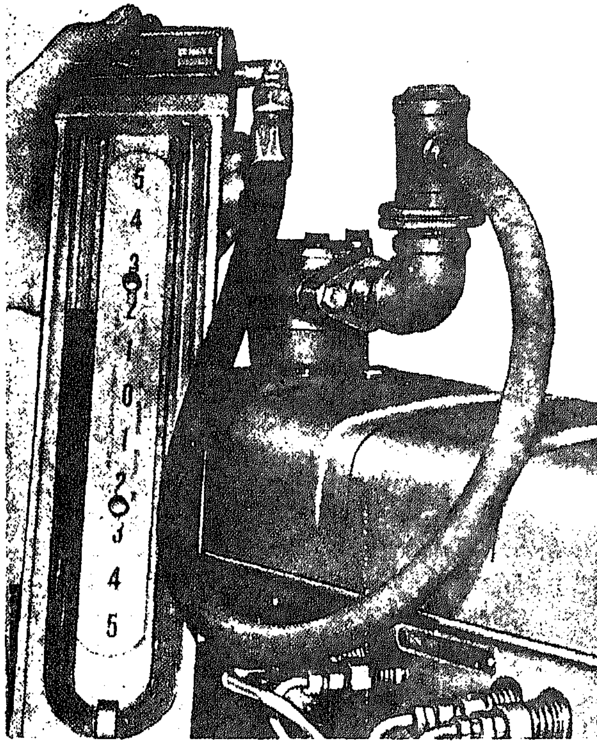


Fig. 5-50. Checking blow-by under load N21

disassembled for repair, install new thrust rings if we *results in end celarance in excess of 0.015 in. [0.3810 m*

The check can be made by attaching an indicator to r against vibration damper or pulley. Push crankshaft towa rear of engine; take reading and pry between cranksh hub and gear cover to bring crankshaft toward front engine. Fig. 5-51. Note reading on gauge. End clearan

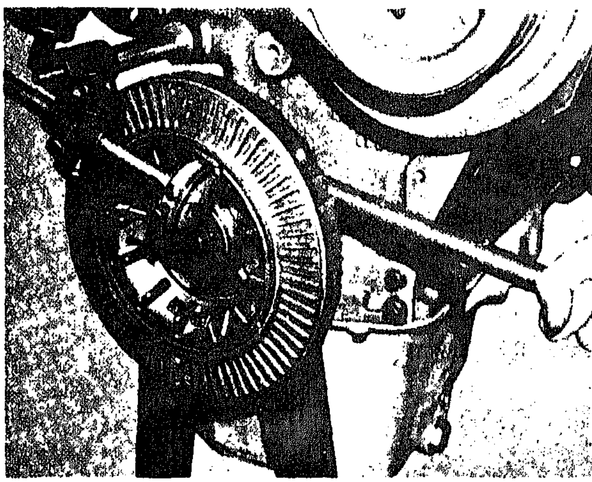


Fig. 5-51. Checking crankshaft end play N2

ust be present with engine mounted in unit and assembled transmission or converter.

nis check may be made at DS level, Replace-ent of crankshaft is GS function.

heck Vibration Damper Alignment (Semi-annual/ 500 hr)

amper hub and inertia member are stamped with an index ark, Fig. 5-52, to permit detection of movement between e two components.

spect damper every DS check. There should be no relave rotation between hub and inertia member resulting from ngine operation.

lajor Inspection

t the determination of the GS maintenance fficer, the engine will be given a ajor inspection to determine whether it may be operated or another service period or if it should be overhauled. Oil onsumption, oil pressure at idling, dilution and other signs f wear should be analyzed as part of the inspection.

ince the major inspection requires partial disassembly of e engine, it should be done only in a well-equipped shop y mechanics thoroughly familiar with worn replacement mits and with disassembly and assembly procedures.

spect the following items at this period:

lain and Connecting Rod Bearing Shells
rankshaft Journals
amshaft Lobes
ylinder Head (Grind Valves)
ylinder Liners
istons and Rings
uel Pump (Calibrate)
njectors (Clean and Calibrate)
upercharger Seals and Bearings
il Cooler (Clean)

ir Compressor
Generator and Cranking Motor
ntake and Exhaust System (Clean and Correct Leaks)

arts that are worn beyond worn replacement limits at this spection should be replaced with new or rebuilt parts or nits.

gine Rebuild

luring the major inspection, it is determined that crankft journals or any other engine parts are worn beyond orn replacement limits, the engine should be removed d completely rebuilt.

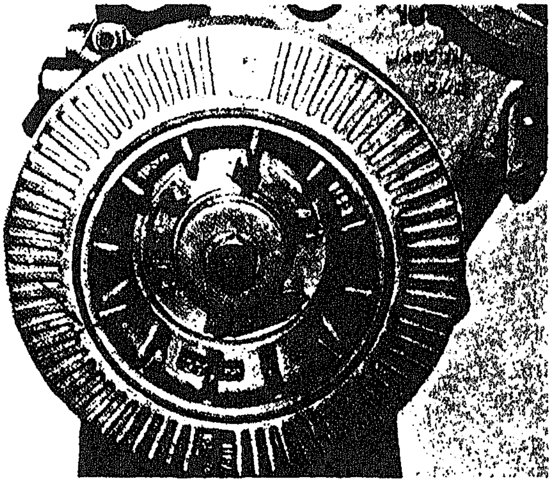


Fig. 5-52. Vibration damper alignment marks N21931

After an engine has been rebuilt it is essentially a new engine and should be treated as such. By treating the rebuilt engine like a new engine and by following the preventive maintenance schedule, the same dependable service can be expected from the engine that it gave during its first service period.

Maintenance Operations Summary Sheet

Information should be collected from each maintenance check sheet and consolidated on a single summary sheet. Each engine thus has an established history and cost records can be computed quickly. A review of the summary sheet will then tell which operations can be reduced or increased to make the maintenance program more effective, resulting in more efficiency from the engine at lower cost. A potential failure caught before it occurs provides savings to the engine owner and a ready-for-service unit for the operator.

PART 3

DIRECT SUPPORT, GENERAL SUPPORT, AND DEPOT MAINTENANCE

GENERAL

Part 3 is written especially for service personnel overhauling the engines and components used thereon. The instructions are as brief as possible yet cover the essential operations necessary to completely disassemble, inspect, repair, assemble and test the complete engine.

Major Sections

Part 3 is made up of several major sections each of which is numbered by group numbers, 0 through 16.

Major sections as listed in the Table of Contents are divided into sub-sections. For example, Group 1, which covers the cylinder block group, contains sub-sections 1 covering the cylinder block, 2 covering cylinder liners, 3 covering idler gear, etc. The Group number appears as a prefix to the section and page numbers on each individual page.

Unit Sections

Each unit contained within an engine group has been assigned a number so unit sections can be removed from the basic manual and taken to that area of the shop concerned with repair of the unit involved.

Page Numbers

Page numbers within the unit sub-section are number consecutively, starting with a new Page 1 at the beginni of each sub-section.

Table Numbers

Tables of dimensions, wear limits and torque values a numbered consecutively by group, section number and w a new Table 1 beginning at the front of each sub-secti

Illustration Numbers

Illustrations are numbered consecutively, beginning w group, section number and figure number at the beginn of each sub-section.

Location of Information

Information regarding a particular part within a gene group, such as a cylinder liner within the cylinder bl group in which it is located, can best be located by us the Table of Contents. Under each Group is listed the u within the group and the group and unit number un which it appears. For example, the cylinder liner is a p of the Cylinder Block Group 1. Found under Group 1, liner carries the unit number 102, as sub-section 2, Group 1.

Parts Dimensions, Wear Limits and Torque Specifications

Parts dimensions are given in Tables within the U

so given in these tables throughout Part 3. Torque pecifications are within the text or tabulated the same as arts dimensions under the applicable unit sub-section.

t the end of Part 3 is Section 16, a complete tabulaon of parts dimensions, worn limits and torque specificaons. The experienced serviceman may prefer to work only om these condensed specifications, unless he is working ith an unfamiliar part or unit.

/orn Limits

/orn limits as stated in this manual indicate that the part ay be reused if it is at the worn limit. Discard only if it xceeds the worn limit. Of course, the reuse of any part is artially the responsibility of the person making the inspecon, as it could well be damaged in an area not listed as worn limit, thus making it unfit for further use.

niversal Units

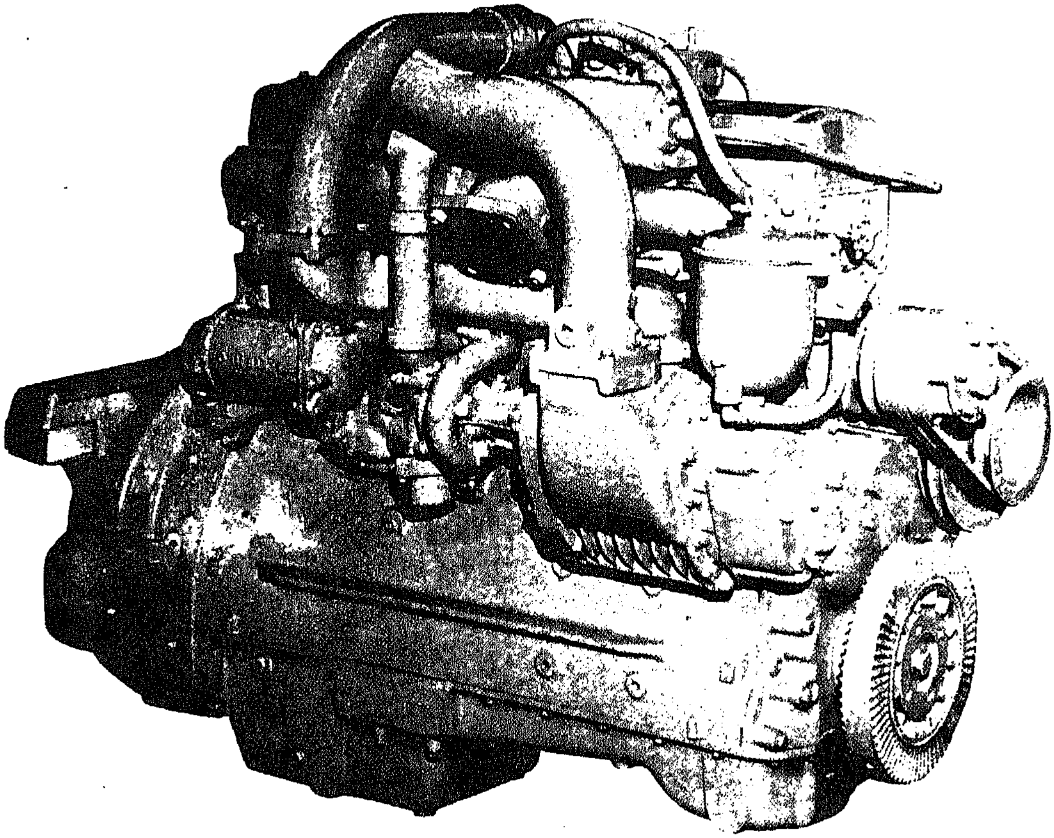
nits such as fuel pumps, injectors, air compressors and irbochargers are also used on other models of ngines. These Group sections are in separate manuals nd so written that they may be used with other engine nop manuals. These units are covered in full detail to ake the information as useful and universally applicable s possible. Only a reference page to the proper separate ianual appears ;
refer to "Table of Contents".

uxiliary Equipment

nits such as hydraulic governors, exhaust brakes, theratic fans, etc. are sometimes used on Cummins Engines nd in many cases are covered in this manual. In other ases, these special units are listed in the group in which ey operate (hydraulic governors with Fuel Pump Group, c.), but information is contained in separate manuals or ust be obtained from the manufacturer.

dditional Information

Information on improvements and changes are reased and arranged using the group and unit number system in order to provide a ready cross reference between his manual, new information and parts. Complete new products as released will be given unit numbers applying to the engine group within which it is used or if necessary a new group can be established.



C-180 Engine

Six-Cylinder Supercharged C		Engine			
Engine Model	**Bore & Stroke In. [mm]**	**Displ. Cu. In. [cu cm]**	**Valves Cylinder**	**Max. Torque @ RPM Ft-Lb [kg m]**	**Max. Hp @ RPM**
C-180	4$\frac{7}{16}$ x 5 [102.0375 x 127.0]	464 [7604.96]	4	425 [58.7775] @ 1700	180 @ 2500

1. Horsepower ratings (stated in U.S. values) established at 29.92 In./Hg barometric pressure (sea level), 60° F [15.5°
   intake temperature, dry air.
2. Derate 3% for each 1000 ft [304.800 m] above sea level and 1% for each 10° F [—12.2° C] rise in air temperatu

Engine Disassembly Group

Unit removal is a simple operation; however, time and lal will be saved if the necessary steps are followed conce ing unit removal. A few simple precautions are included this manual that will help to prevent accidents and/or da age to the parts involved.

Unit Removal

Before disassembly of an engine, or any unit used on the engine, inspection of the over-all condition should be made and as much history as possible should be collected. These two items will provide clues to reasons for failure, if one occurred, and will furnish a great deal of information concerning necessary repair.

Inspection of each unit removed and tagging of electrical wires, bearing shell positions and other parts identification will help to insure correct assembly during the assembly operations.

Remove units and parts from cylinder block in the following order, paying particular attention to the precautions noted. Place removed parts and units (except electrical parts or those that could be damaged by steam cleaning) on a rack or cart for steam cleaning.

Drain Oil, Water and Fuel

1. Drain lubricating oil from oil pan, oil filters, oil cooler, hydraulic governor and air compressor.

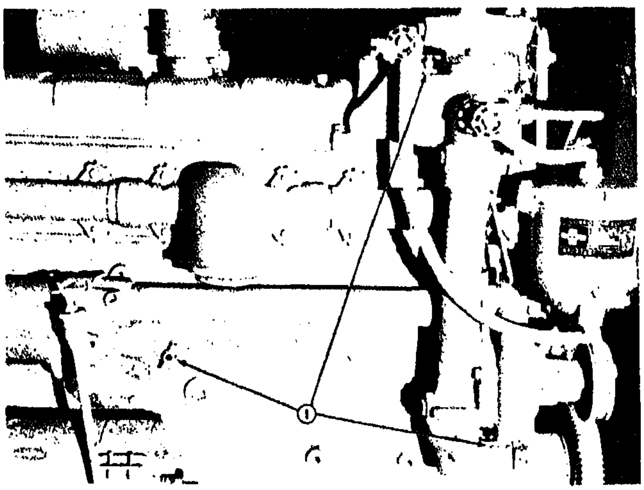


Fig. 0-1. Coolant vent and drain points N20001

2. Drain fuel from fuel pump, fuel filter, fuel lines and fu pump float tank (if used).
3. Open vent and drain cocks (1, Fig. 0-1), remove drain plu and drain coolant from cylinder block, radiator, oil coo and heat exchanger.
4. Bleed compressed air system (when used).

Remove Engine From Unit

Use Lifting Fixture (Fig. 0-2) to remove engines fr chassis when rear of engine is mounted under fire wall. T tool spans four cylinders and provides three lifting poi to compensate for different weight distributions

Engine Serial Number Plate

1. Location of engine serial number plate is shown in Fig. (

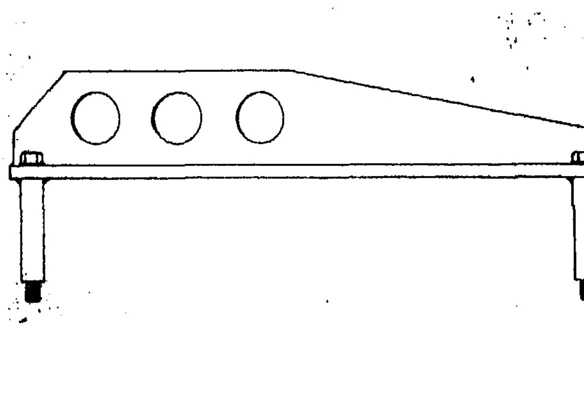
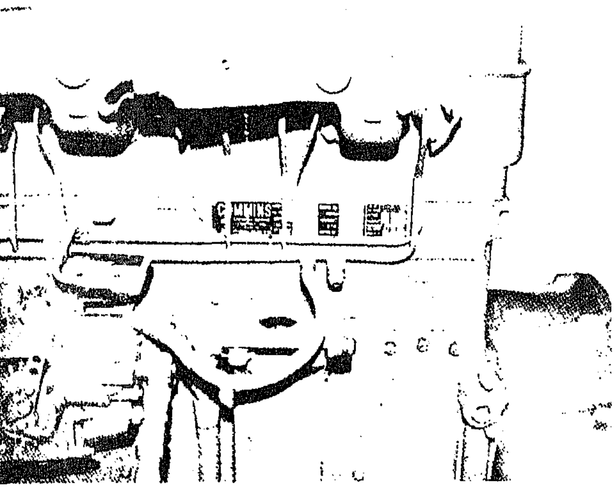


Fig. 0-2. ST-464 Lifting Fixture ST



ig 0-3. Engine Serial number plate location N20031

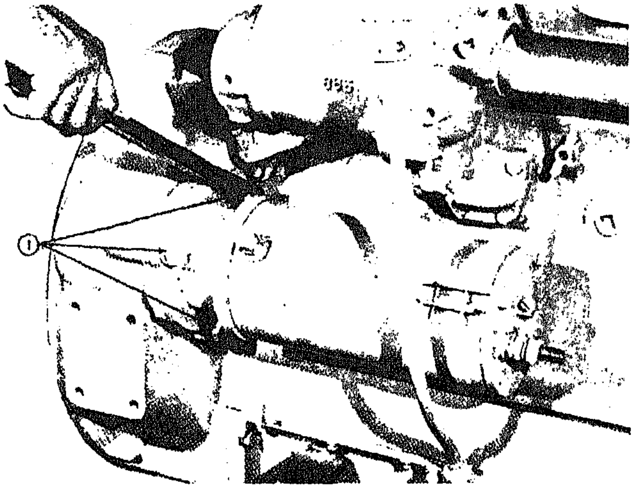


Fig. 0-4. Removing cranking motor N20003

lways refer to engine serial number and model designa-ion when ordering parts or assemblies.

f the camshaft, pistons and/or rings are changed from hose shown on the serial number plate, the correct part umbers should be stamped on the plate. This information s often vital to fuel pump calibration and satisfactory en-ine performance.

Caution: Do not change engine serial number.

Electrical Connections

isconnect and **tag** all electrical leads from terminals of enerator, cranking motor, cold-starting glow plug, fuel ump solenoid, regulator, remote control, etc., as used on ngine.

emove all electrical controls and wiring.

Cranking Motor

lectric

isconnect leads from cranking motor terminals (if not pre-iously removed).

emove capscrews (1, Fig. 0-4) and lockwashers securing ranking motor and spacer (if used) to flywheel housing.

lide cranking motor out and remove from engine.

Generator

1. Remove adjusting capscrew (1, Fig. 0-5), lockwasher, flat-washer and nut securing generator to adjusting bar.
2. Loosen mounting bolts; move generator toward engine and

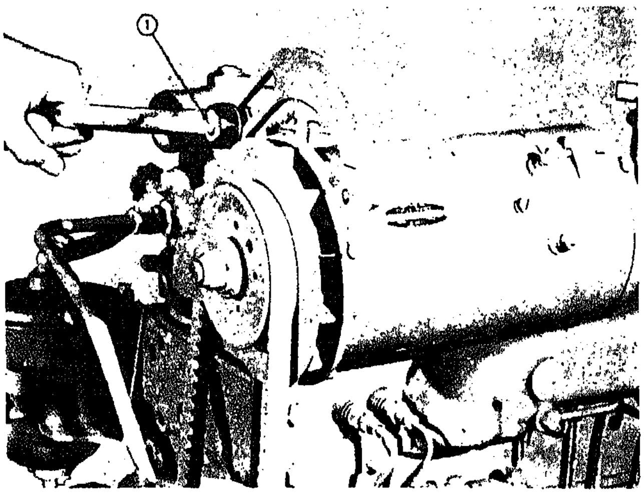


Fig. 0-5. Removing generator belt adjusting screw N20004

disengage drive belt.

3. Remove capscrews and lockwashers securing generator to mounting bracket; lift generator from engine.

4. Remove capscrews, lockwashers and flatwashers securing mounting bracket(s) to engine; remove bracket(s).

Note: On some applications it may be easier to remove generator and bracket as a unit.

Steam Clean Engine Exterior

A portable steam cleaner is very satisfactory for general use. Exterior cleaning makes the unit easier to work on, reduces possibility of building dirt back into the engine and inspection can be made more easily and accurately during disassembly if surfaces are clean.

Mechanical Controls; Water, Air and Fuel Connections

1. Remove mechanical control linkage (clutch linkage, throttle linkage, etc.).
2. Remove water connections (radiator hose, water by-pass tubes, etc.).
3. Not applicable.
4. Remove flexible fuel lines from injector fuel drain manifold and pump inlet (or fuel filter, if so equipped).
5. Remove air cleaner-to-engine hose connection.
6. Remove air outlet line from compressor.

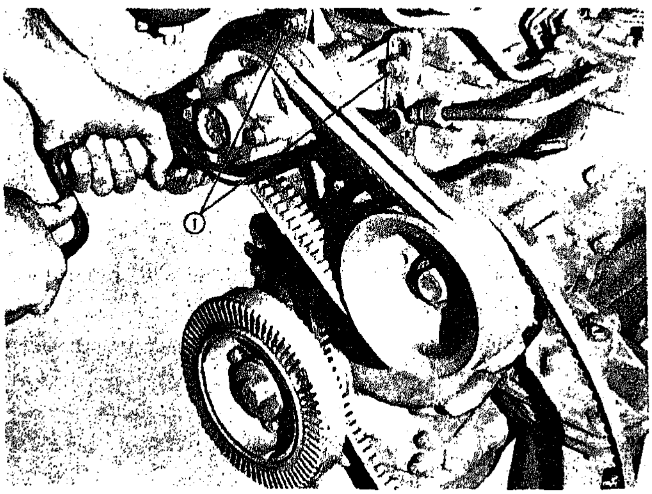


Fig. 0-6. Removing fan bracket mounting capscrews N20032

Fan, Fan Hub and Mounting Bracket

1. Remove capscrews and lockwashers securing fan to hub; remove fan.
2. Loosen big fan hub nut(s) (behind hub).
3. Turn eccentric shaft or adjusting screw to relieve belt sion; remove belts.
4. Remove fan hub bracket mounting capscrews (1, Fig. (lockwashers and flatwashers; lift fan hub and bracket sembly from engine.

Full-Flow Lubricating Oil Filter

Block-Mounted

Remove mounting capscrews and lockwashers secu filter head to block. Lift filter and head assembly from gine; discard gasket.

Remote-Mounted

1. Disconnect and remove oil lines.
2. Remove capscrews and lockwashers securing regula filter line connection to block.
3. Remove capscrews and lockwashers securing filter mo ing bracket to engine.

Note: Filter may be located on equipment frame or ano location.

Corrosion Resistor

1. Close shut-off valves on coolant inlet and outlet lines; move drain plug in filter housing and drain coolant.
2. Disconnect coolant inlet and outlet lines and remove f engine.
3. Remove capscrews, lockwashers, flatwashers and nuts curing filter to mounting bracket, Fig. 0-7; lift filter ass bly from engine.
4. Remove mounting bracket capscrews and lockwashers; bracket from engine.

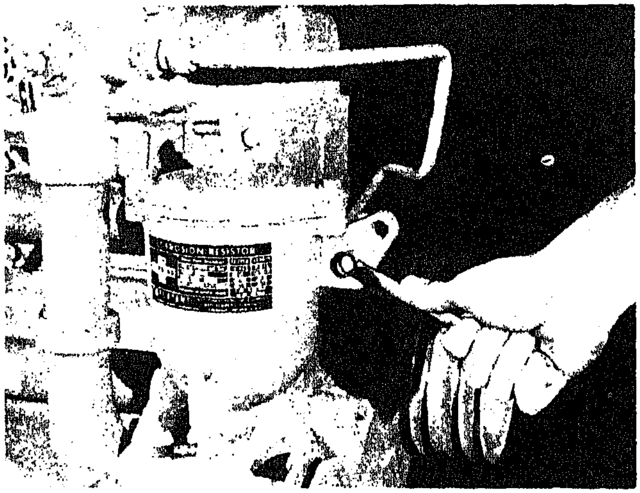


Fig. 0-7. Removing corrosion resistor capscrews N20002

PT Fuel Pump

1. Remove pump by-pass or fuel coolant line (if used), Fig. 0-10.
2. Remove fuel line from solenoid shutdown valve to fuel supply manifold, Fig. 0-11.
3. Disconnect return line (if used) from top of fuel pump.
4. Remove fuel pump mounting capscrews and lockwashers

and lift fuel pump from engine, Fig. 0-12; discard gask

5. Remove and discard drive spider or buffer from coupli

Caution: Do not lose coupling retainer, rubber buffe coupling collar from fuel p drive,

Accessory Drive Pulley

1. Remove nut and flatwasher securing drive pulley to c pressor crankshaft. (In some cases, capscrews are use hold pulley to crankshaft.)
2. Install Puller to drive pulley with two capscr turn center screw clockwise until pulley is loose, Fig.
3. Remove pulley; remove key from crankshaft.

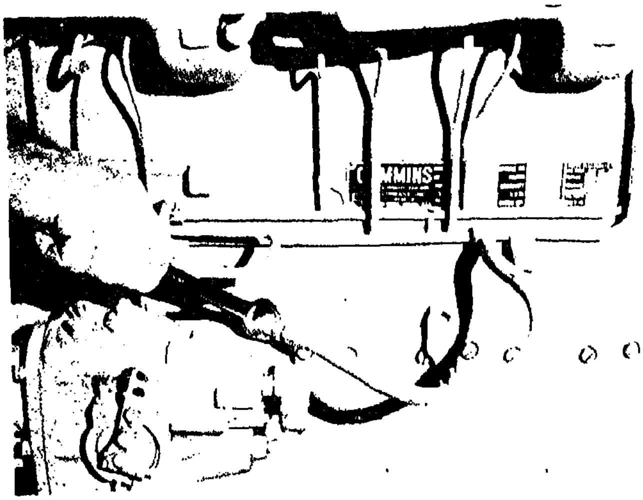


Fig. 0-10. Removing fuel pump coolant line

N20034

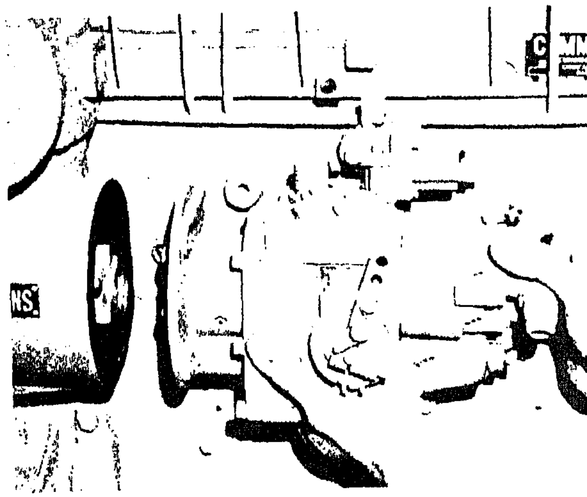


Fig. 0-12. Removing fuel pump

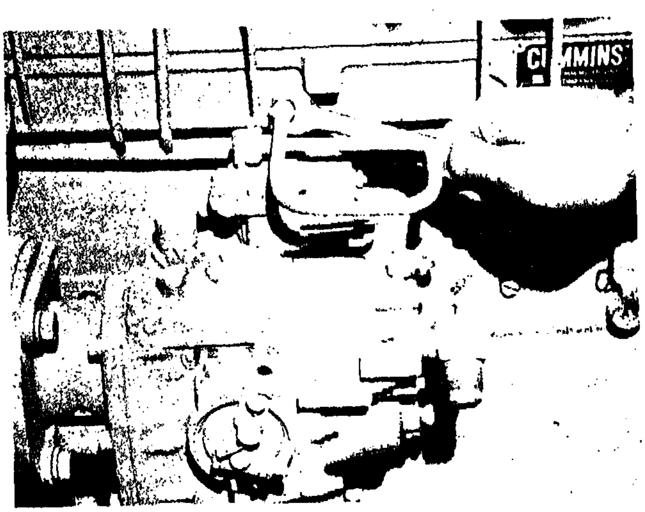


Fig. 0-11. Disconnecting fuel supply tube

N20038

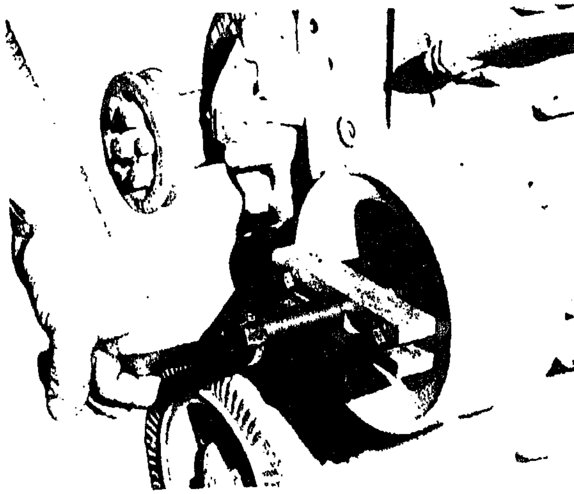


Fig. 0-13. Removing accessory drive pulley

ir Compressor

air compressor is flange-mounted to the gear :over and is gear-driven off the camshaft.

)isconnect water inlet and outlet tubes, Fig. 0-14; lift from ·ngine.

?emove tube (if used) from intake manifold to compressor nlet.

?emove capscrews and lockwashers securing compressor ;upport to gear cover, Fig. 0-15; lift compressor and sup-)ort from engine and discard gasket.

Jote: One capscrew is located on back of compressor ;upport, while the others are on front of gear cover.

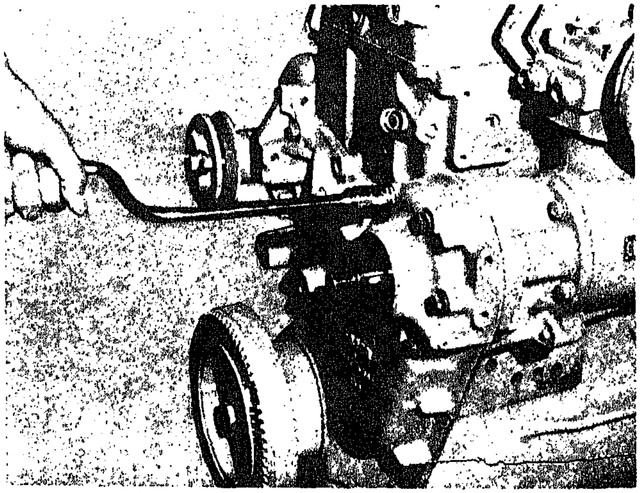
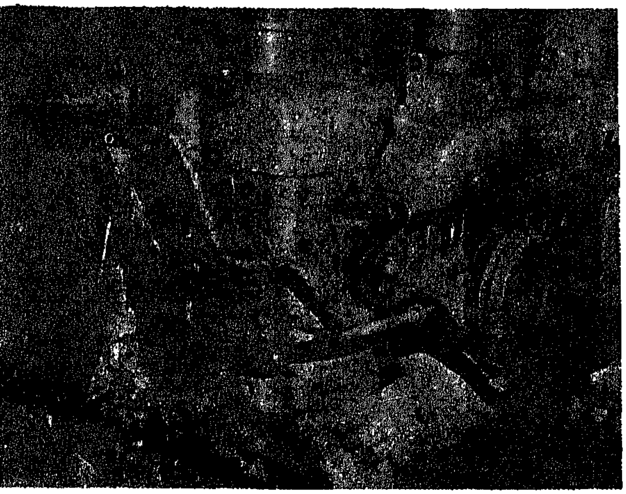


Fig. 0-15. Removing air compressor support capscrews N20036



'ig. 0-14. Disconnecting air compressor water lines N20035

Transfer Connection

1. Remove capscrews, lockwashers and flatwashers from oil transfer connection, Fig. 0-16.
2. Remove connection from block and discard gaskets.

Oil Passage Plugs

Remove the three oil passage plugs from block (1, Fig. 0-17) on fuel pump side of engine.

Mount Engine To Stand

1. Place Lifting Fixture over cylinder head cover.
2. Screw lifting screws tightly into tapped holes provided in top of cylinder head; lift engine, Fig. 0-18.

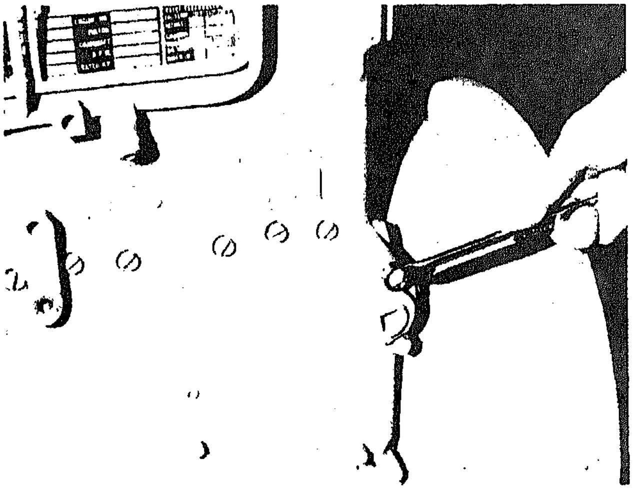
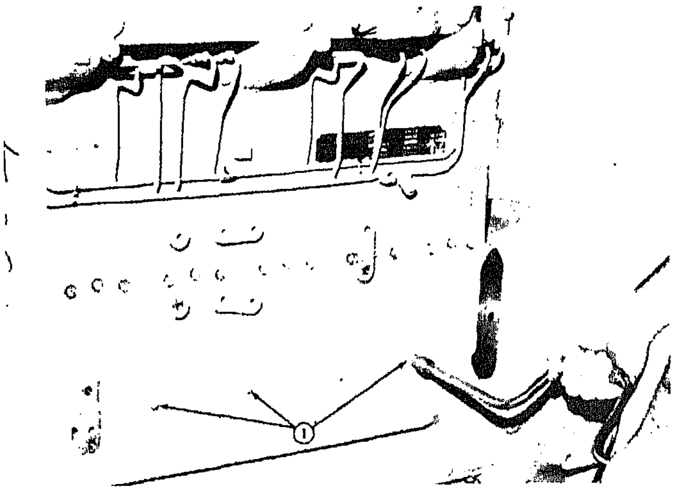


Fig. 0-16. Removing capscrews from oil transfer connection N20037



. 0-17. Removing oil passage plugs N20038

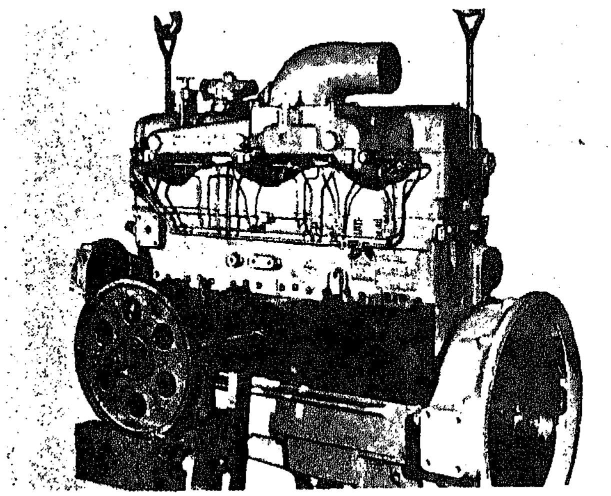


Fig. 0-18. Lifting and mounting engine to Engine Stand N20010

3. Mount engine on fuel pump side with six capscre Engine Stand and adapter.

Caution: Make sure engine is fastened securely stand.

Intake Manifold (Fuel Pump Side)

1. Remove mounting capscrews and copper washers air intake manifold to head.
2. Lift manifold from head, Fig. 0-19; discard gaske
3. On supercharged engines, disconnect air outlet supercharger connection and manifold; then perf 1 and 2.

Fuel Manifolds

Disconnect fuel inlet and drain manifolds from co in cylinder head; lift manifolds from engine, Fig

Inlet and Drain Connections

1. Place wrench on nut closest to spring and scre tions out of injector; repeat this procedure unt nections are loose, Fig. 0-21.
2. Pull each connection out of cylinder head.

Oil Gauge Tube and Bracket

1. Remove capscrews and lockwashers securing

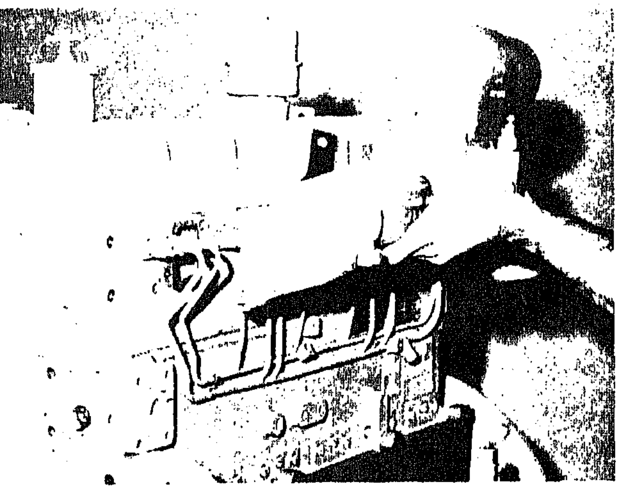


Fig. 0-19. Removing air intake manifold N20039

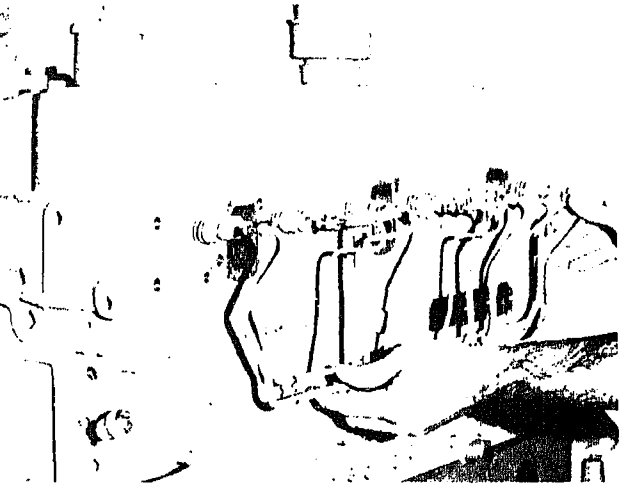


Fig. 0-20. Removing fuel inlet and drain manifolds N20040

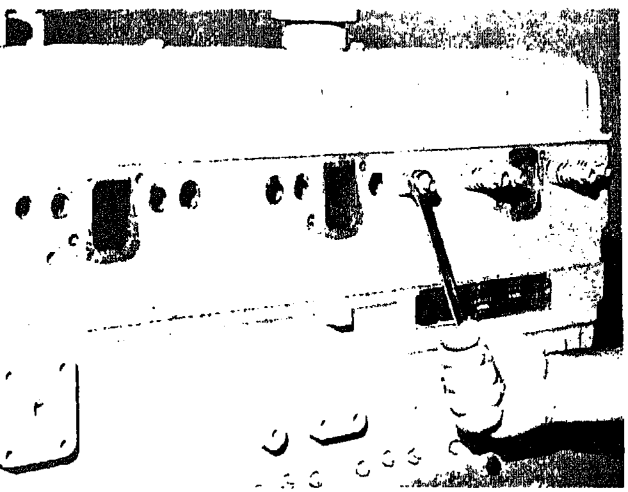


Fig. 0-21. Loosening fuel inlet and drain connections N20013

oil pan, Fig. 0-22.

2. Because the dipstick tube extends down into the oil pan it will be necessary to lift bracket and tube assembly up and away from pan in order to clear slanted hole in oil pan; discard gasket.

Lubricating Oil Cooler

1. Disconnect and remove any external oil or water lines from cooler.
2. Remove capscrews and lockwashers securing cooler housing and cover assembly to block; remove cooler assembly and gaskets from engine, Fig. 0-23; discard gaskets.
3. Remove water tube and tube "O" rings; discard "O" rings.

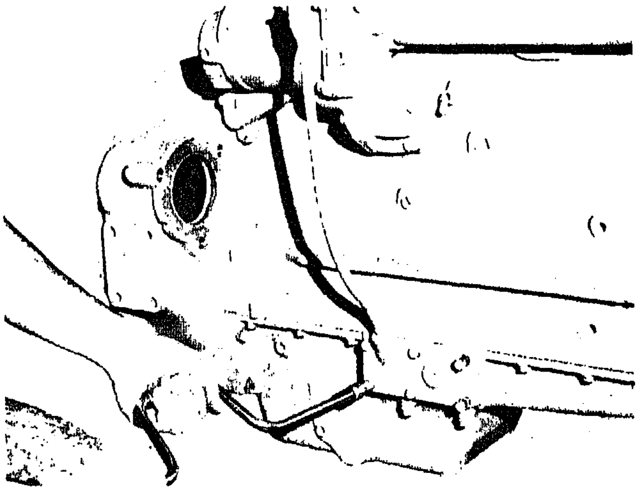


Fig. 0-22. Removing dipstick tube bracket capscrews N20041

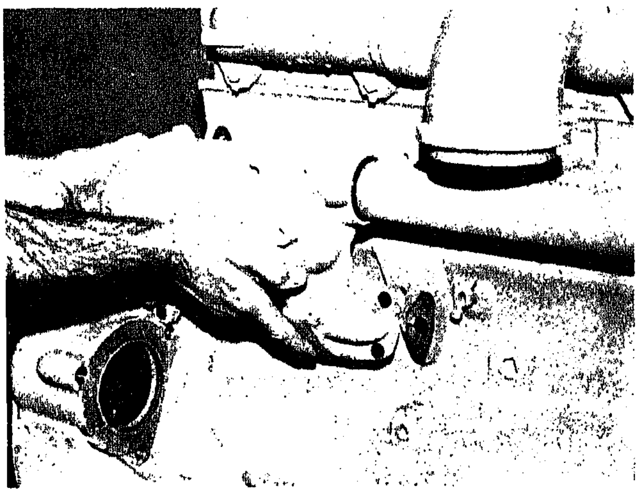


Fig. 0-23. Removing oil cooler assembly N20014

Supercharger Air Intake Connection

1. Remove vapor suction tube (if used) from side of supercharger intake connection to cylinder head cover.
2. Remove capscrews and lockwashers securing connection to supercharger; lift off connection and discard gasket.

Caution: Cover inlet port of supercharger with gummed tape to prevent dirt entry.

Thermostat Housing and Water By-Pass Connection

Six-Cylinder Engine

1. Remove water pump air bleed tube, Fig. 0-24.
2. Remove capscrews and lockwashers mounting thermostat housing and by-pass connection to cylinder head.
3. Lift thermostat housing (1), by-pass connection (2), and by-pass coupling(s) (3), off engine, Fig. 0-25.
3. Remove connection and gasket; discard gasket.

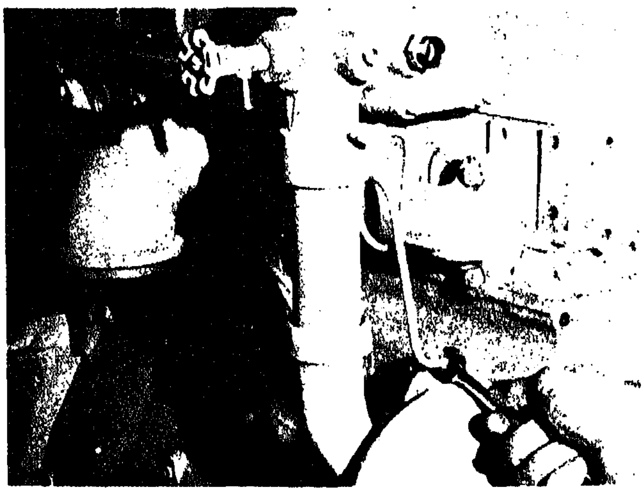


Fig. 0-24. Removing air bleed tube N20042

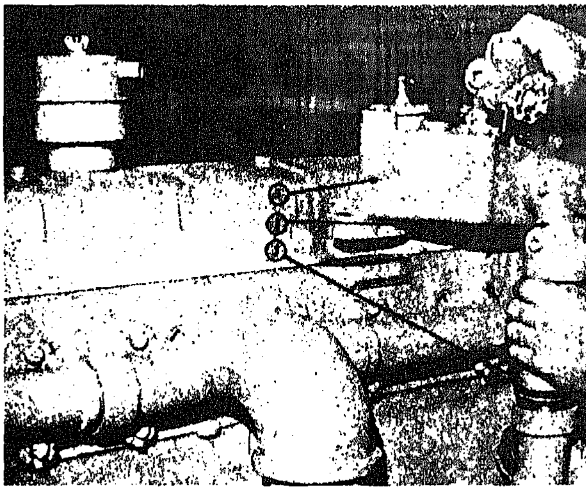


Fig. 0-25. Removing thermostat housing assembly N

Exhaust Manifold

1. Remove two center capscrews securing manifold to he insert two threaded studs into head.
2. Remove remaining capscrews and slide manifolds back off the engine, Fig. 0-26.
3. Discard all gaskets and lockplates.

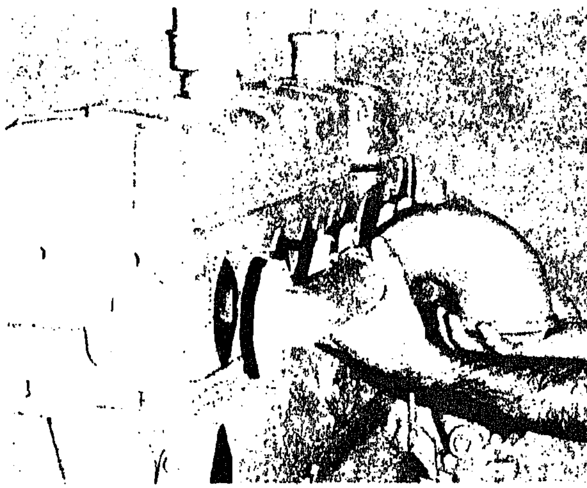


Fig. 0-26. Removing exhaust manifolds N

Water Pump

Remove mounting capscrews and lockwashers ş water pump to supercharger.

lote: Supercharger-driven pump mounts to, and is driven y, the supercharger.

Vater Header Plate

Remove capscrews and lockwashers securing plate to lock.

Remove plate and gasket from engine, Fig. 0-28; discard asket.

Supercharger

Remove capscrews and lockwashers securing supercharger o gear cover, Fig. 0-29.

Lift supercharger from gear cover, being careful not to lamage lubricating oil ferrule in gear cover close to lower upercharger dowel.

Rocker Lever Cover

Remove capscrews and seals securing cover to cylinder head.

2. Lift cover and gasket from head, Fig. 0-30; discard gasket.

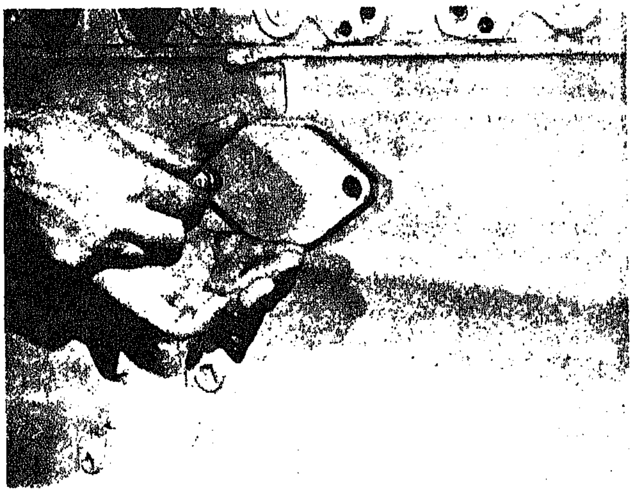


Fig. 0-28. Removing water header plate capscrews N20044

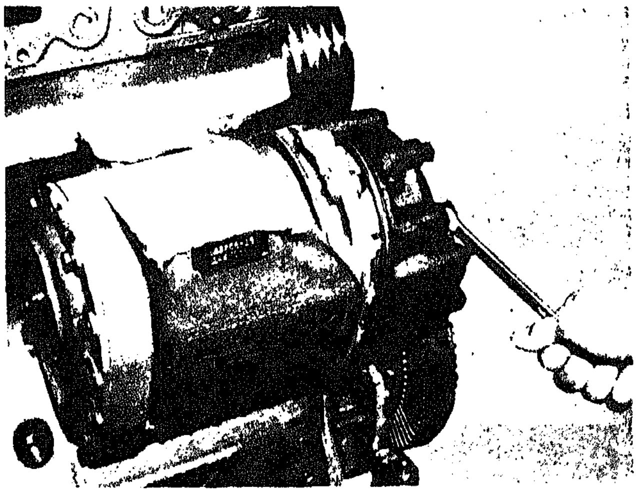


Fig. 0-29. Removing supercharger capscrews N20064

Rocker Lever Assembly

1. Loosen all injector and valve rocker lever locknuts and back off adjusting screws one or two turns. Fig. 0-31.
2. Remove capscrews and flatwashers securing rocker lever assembly and cylinder head to block, Fig. 0-32.
3. Carefully pry rocker lever assembly from dowels.
4. Using a bar or wooden slat to hold levers in position, lift rocker lever assembly from engine, Fig. 0-33.

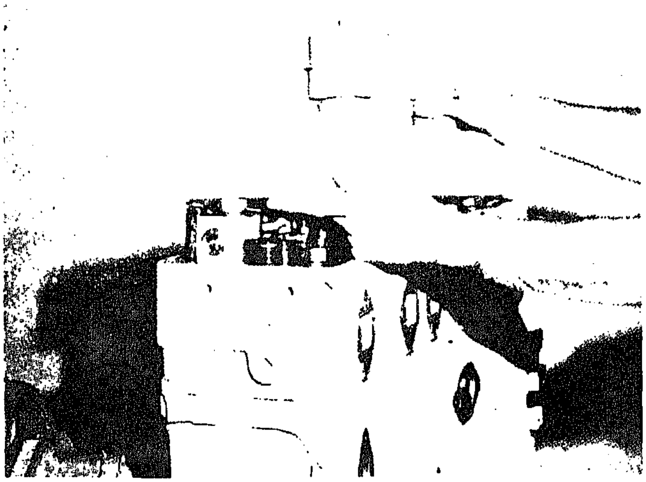


Fig. 0-30. Removing cylinder head cover N20045

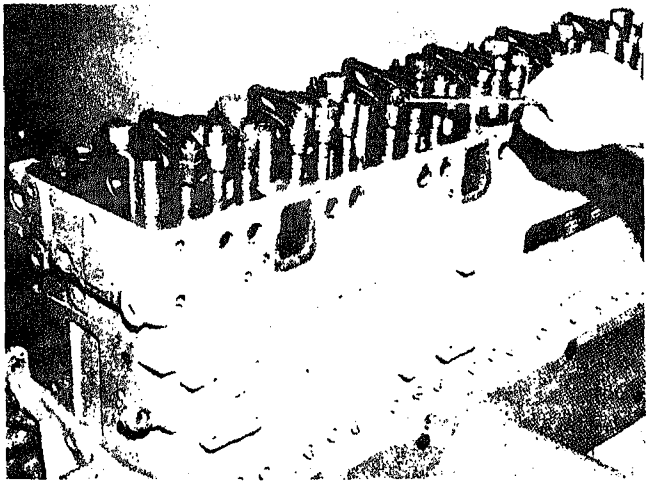


Fig. 0-31. Loosening rocker lever jam nuts N20046

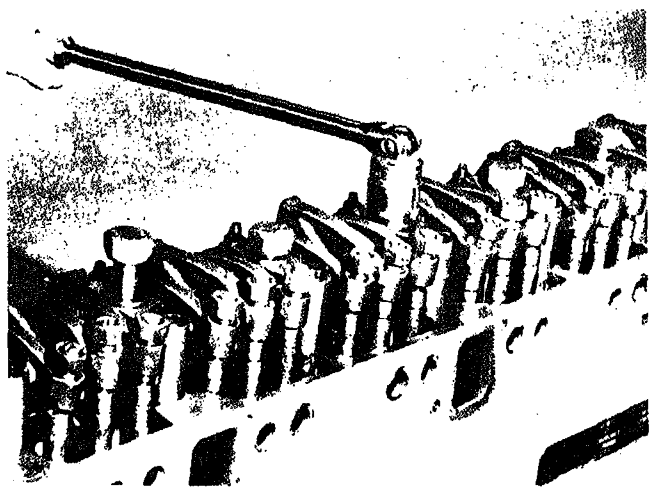


Fig. 0-32. Removing cylinder head mounting capscrews N20047

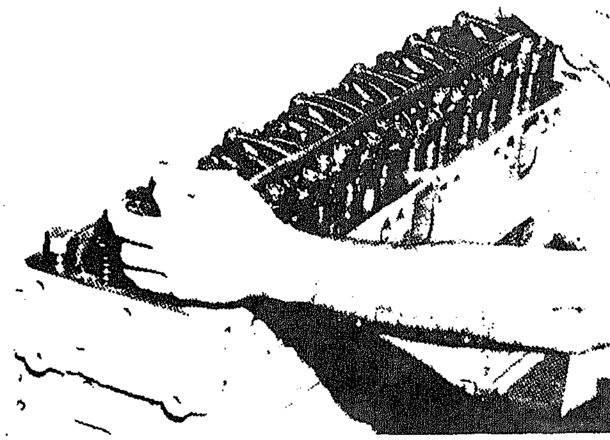


Fig. 0-33. Removing rocker lever assembly N2004

Push Tubes and Valve Crossheads

1. Lift all push tubes from tappet sockets, Fig. 0-34.
2. Lift valve crossheads from crosshead guides, Fig. 0-35. I some cases these may be left in cylinder head and th complete unit sent to the head repair section.

Injectors

1. Remove injector hold-down capscrews.
2. Pry injectors loose and remove from head, Fig. 0-36, bein careful not to damage injector cup tips.
3. Number each injector according to the cylinder from whic it was removed; place in drain rack.

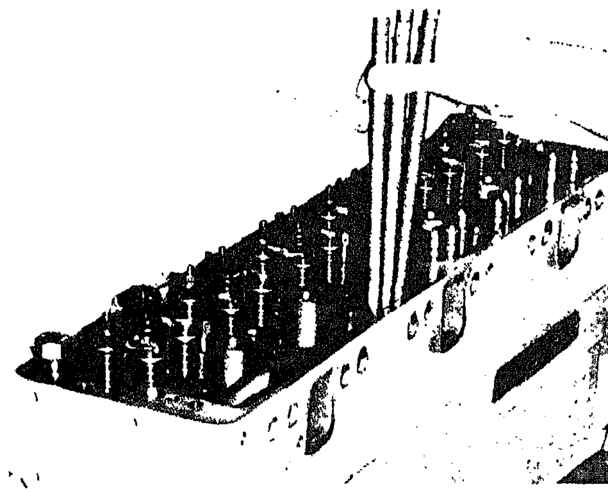


Fig. 0-34. Removing push tubes N20

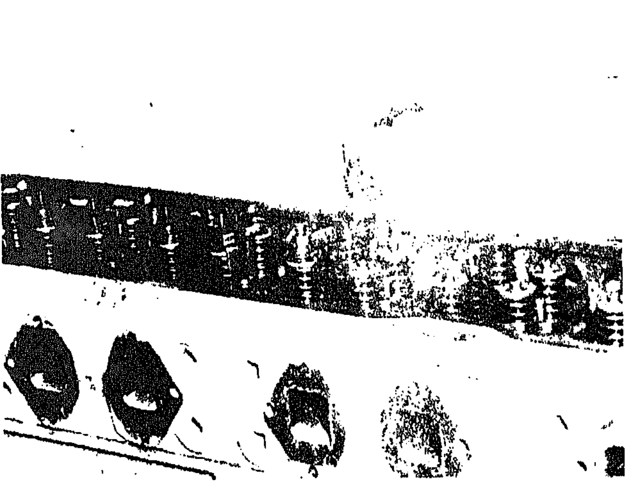


Fig. 0-35. Removing valve crossheads N20050

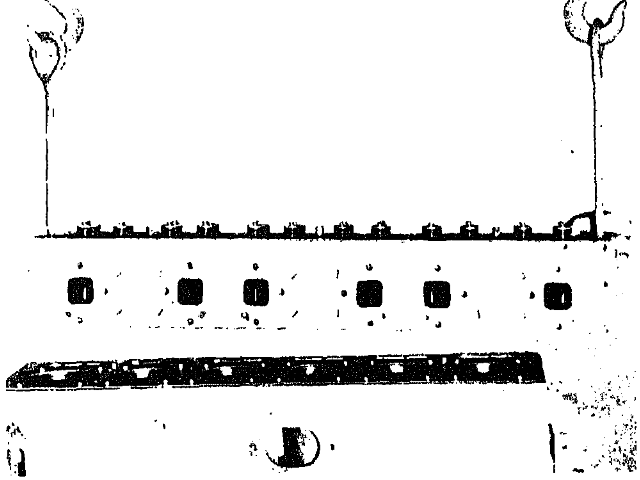


Fig. 0-37 Lifting cylinder head N20051

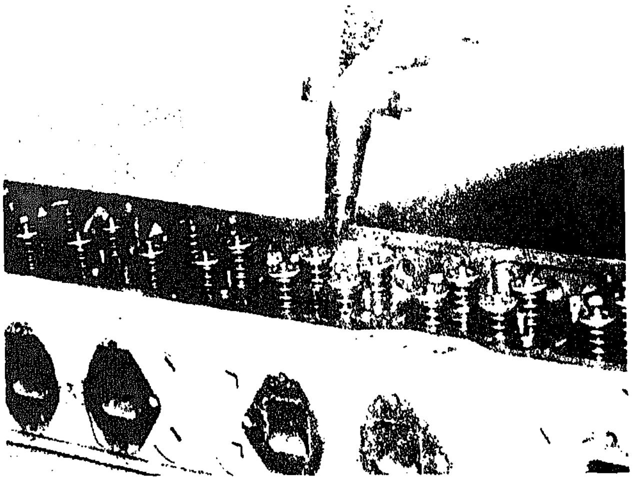


Fig. 0-36. Removing injectors N20019

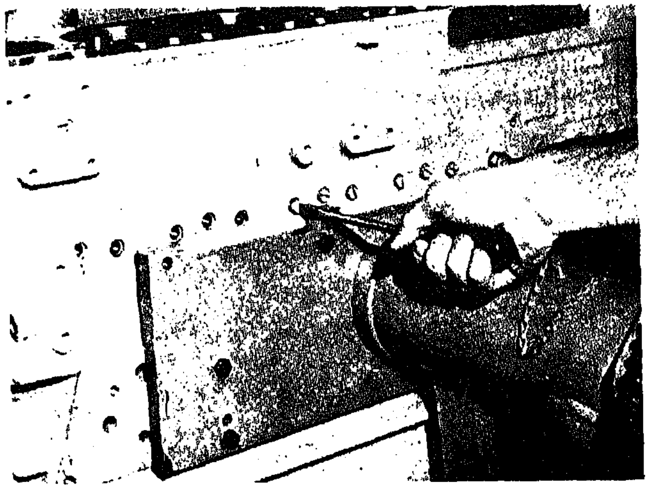


Fig. 0-38. Removing tappet guide screws N20020

Cylinder Head

Attach Lifting Fixture to cylinder head and, using a suitable hoist, lift head from block, Fig. 0-37.

Note: Do not allow machined surface of head to be scratched or nicked; slight damage could result in lack of combustion seal during operation of engine.

. Remove and discard head gasket, grommets and retainers.

Tappets and Tappet Guides

. Remove tappet guide screws from side of block, Fig. 0-38.
. Using a wire with a hook on one end, hook wire into tappet guide slot (located on side of tappet nearest the outside wall of block) and lift tappets from engine.

Flywheel

1. Remove lockwires (if used) and all but two capscrews; or, remove all but two capscrews and washers (if used) securing flywheel to crankshaft; insert one or two guide studs in vacant capscrew holes.
2. Remove remaining capscrews and washers (if used) and pull flywheel from crankshaft, Fig. 0-39.

   Note: If necessary, insert two capscrews into holes in flywheel and tighten equally to free fly n crankshaft.

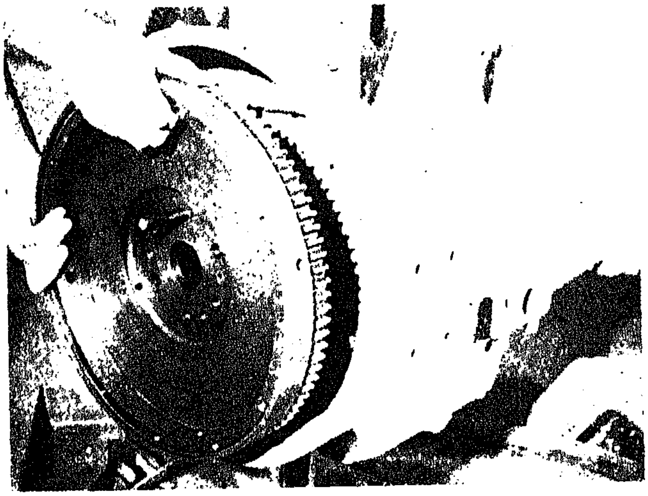


Fig. 0-39. Removing flywheel N20021

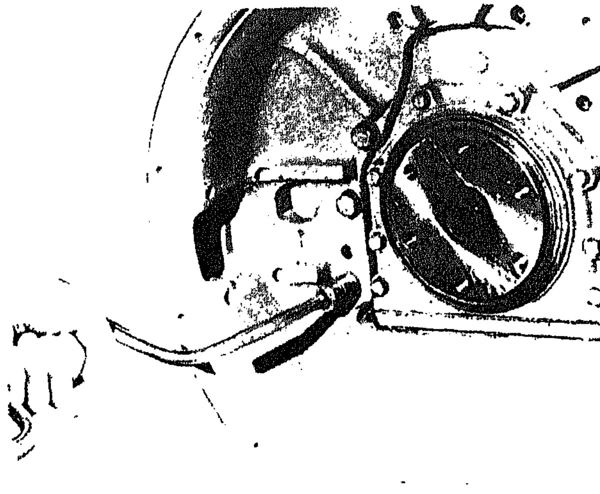


Fig. 0-40. Removing flywheel housing capscrews N20

Flywheel Housing

1. Remove capscrews, lockwashers and flatwashers securing flywheel housing to oil pan; remove capscrews, lockwashers and flatwashers securing housing to block, Fig. 0-40.
2. Using a soft hammer, tap housing away from engine.

Oil Pan

1. Turn engine upside down.
2. Remove all mounting capscrews, lockwashers and flatwashers from pan.
3. Lift oil pan and gasket from block, Fig. 0-41; discard gasket.

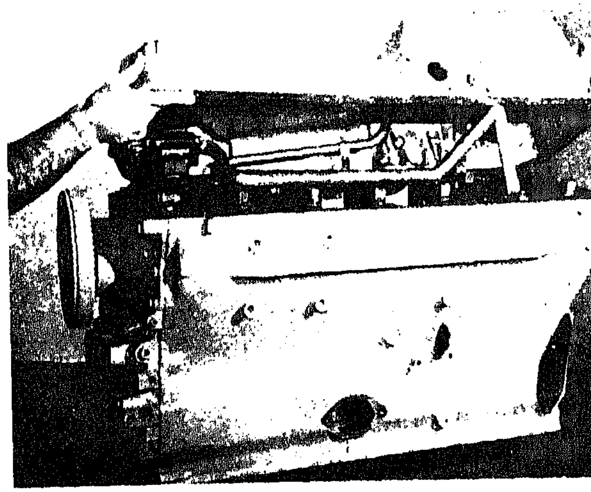


Fig. 0-41. Removing oil pan N2

Oil Drain Tube

Remove capscrews, lockplates and lockwashers securing tube (1, Fig. 0-42) and bracket to block; lift tube and bracket from engine.

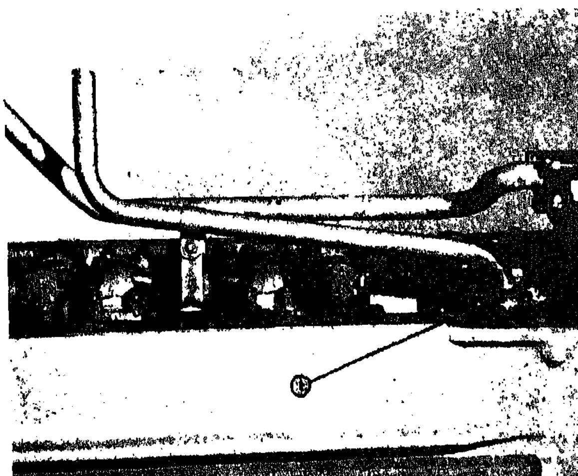
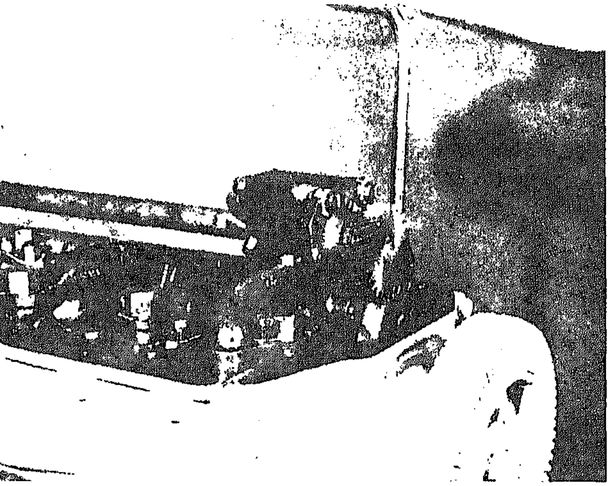


Fig. 0-42. Removing drain tube capscrews N

Lubricating Oil Pump

Oil Pan-Enclosed

1. Remove capscrews and lockplates securing oil pump, Fig. 0-43, and suction tube strap to block.
2. Lift pump and tube assembly from block.



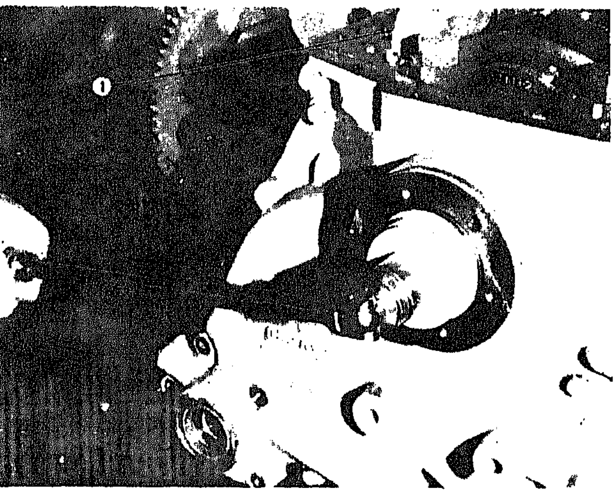
ig. 0-43. Removing oil pump capscrews N20054

/ibration Damper and Hub

lace a wooden block between a crankshaft counterweight nd cylinder block wall to prevent crankshaft from turning , Fig. 0-44).

)isengage lockplates and remove capscrews securing amper to hub, Fig. 0-45; remove damper.

!emove capscrew and flatwasher securing hub to crank-



ig. 0-44. Removing vibration damper capscrews N20055

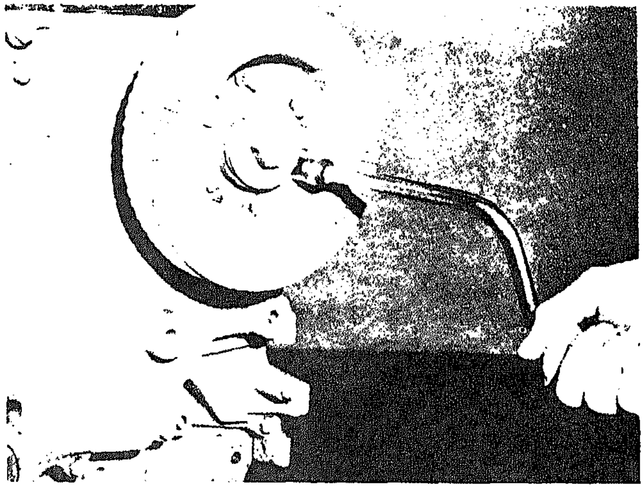


Fig. 0-45. Removing crankshaft hub capscrew N20030

shaft, Fig. 0-44.

4. Using Puller, pull hub from crankshaft, Fig. 0-46.

Gear Cover

1. Remove all capscrews and lockwashers securing cover to block (including two capscrews behind mounting plate, Fig. 0-47). Lift gear cover from engine.
2. Remove and discard gasket.

Note: Gear cover on supercharged engine has an idler spindle support screw that must be removed before removing gear cover.

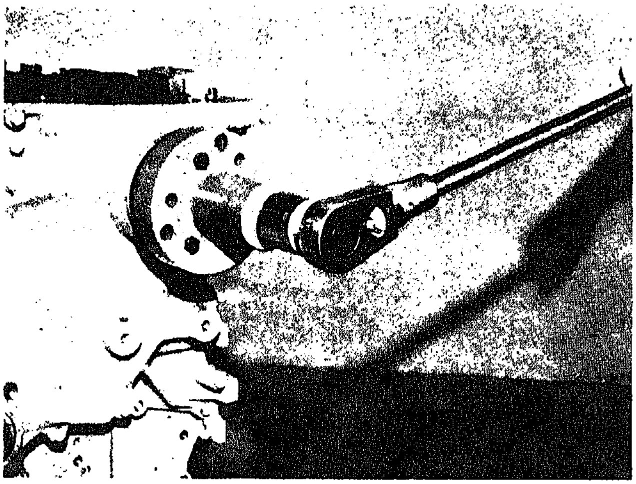


Fig. 0-46. Pulling crankshaft hub with Puller N20023

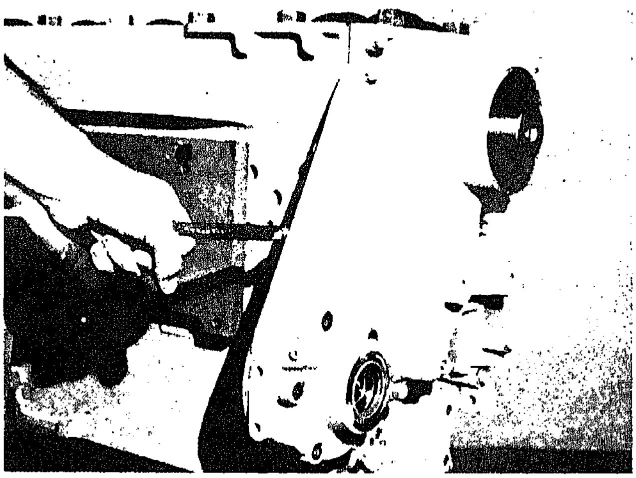


Fig. 0-47. Removing gear cover capscrews N20056

Supercharger Idler Gear

Remove idler gear assembly; remove front and rear thrust bearings from idler shaft.

Camshaft

1. Since the crankshaft oil slinger partially covers the camshaft gear, remove slinger mounting capscrews and lockplates, Fig. 0-48, and remove slinger from crankshaft; discard lockplates.
2. Remove capscrews and lockwashers (accessible through openings in camshaft gear) securing camshaft retainer bearing to block.
3. Rotate camshaft gear slightly to disengage gear teeth

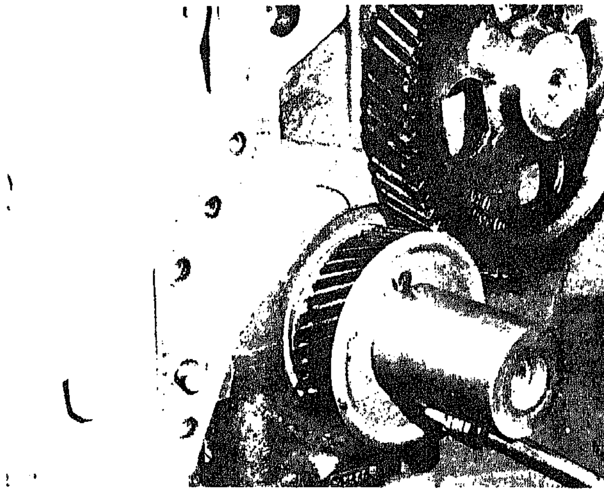


Fig. 0-48. Removing oil slinger capscrews N2

while carefully pulling camshaft, camshaft gear and be ing plate from block, Fig. 0-49.

Gear Cover Mounting Plate

Remove capscrews and lockwashers securing plate block, Fig. 0-50; tap plate from block with lead or plas hammer. Discard gasket.

Rear Cover and Seal

Remove capscrews and lockwashers securing cover block; slide cover and seal assembly off the cranksh

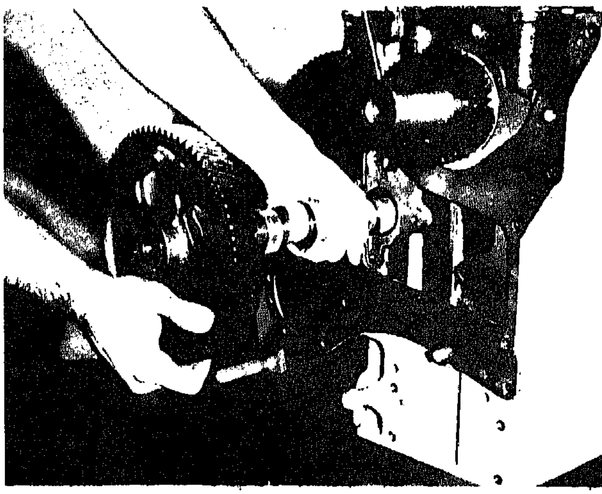


Fig. 0-49. Removing camshaft N

ange, Fig. 0-51; discard seal.

Connecting Rod and Piston Assemblies

urn engine right-side-up and clean all carbon from upper nside wall of each cylinder liner with ridge reamer and fine mery cloth or equivalent, Fig. 0-52.

o facilitate removal of rod and piston assemblies, turn engine until crankshaft is in vertical position.

emove connecting rod "U"-bolt nuts and lockplates; pull aps and bearing shells from connecting rods, Fig. 0-53.

ush connecting rod and piston assemblies from cylinder iners with wooden stick, holding pistons so they will not

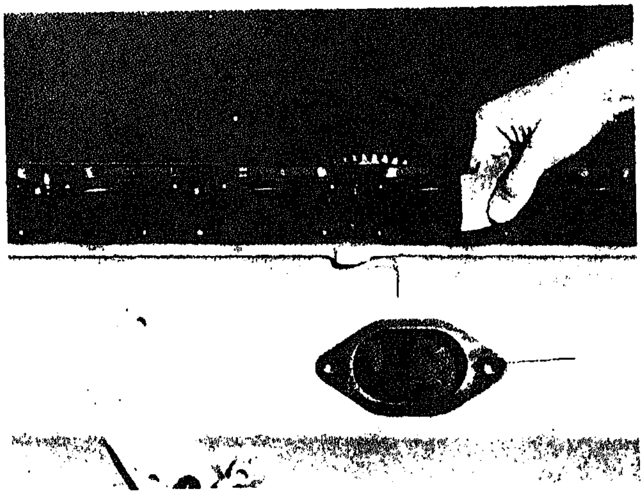


Fig. 0-52. Cleaning cylinder liner with emery cloth N20059

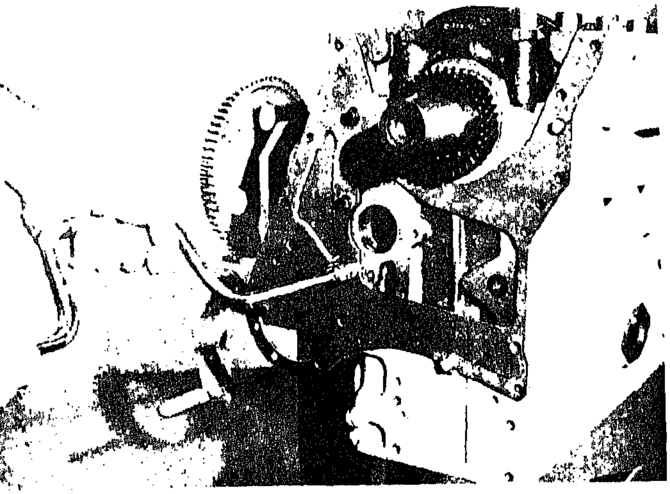


Fig. 0-50. Removing mounting plate capscrews N20058

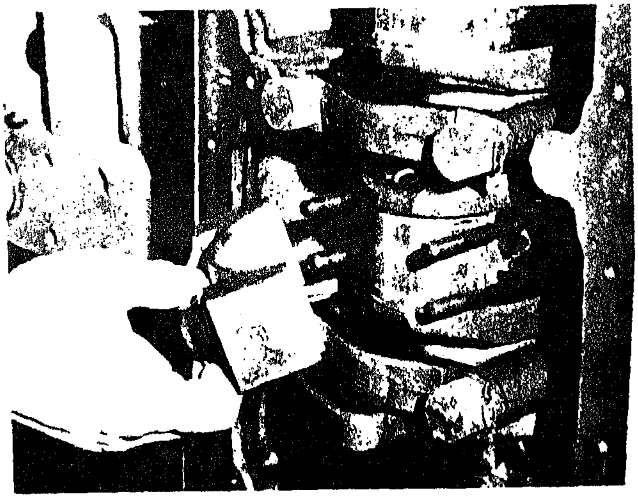


Fig. 0-53. Removing connecting rod cap N20060

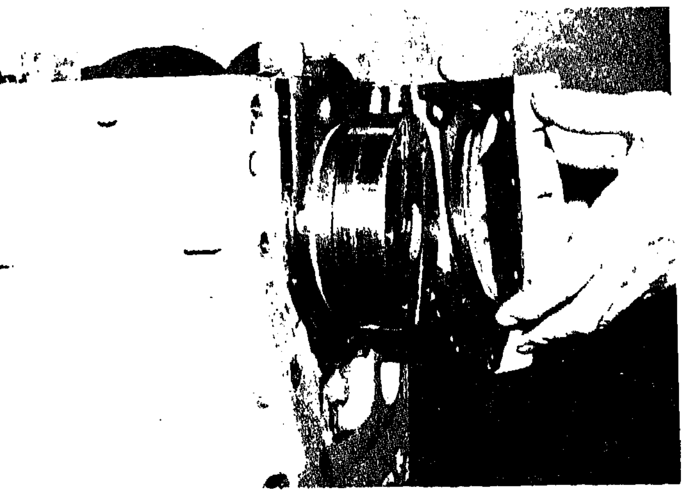


Fig. 0-51. Removing rear cover N20025

be dropped and damaged.

Caution: Do not mutilate inner walls of cylinder liners.

5. Reassemble each connecting rod cap to assembly as it is removed, Fig. 0-54; the rod caps are not interchangeable. Label each assembly by cylinder number; tape mating bearing shells together and label each pair by cylinder number for later reference.

   Note: Check each rod and cap as removed to make sure it is stamped, in case of mixing, so all parts are reassembled correctly. Likewise, if a new assembly is to be used be sure to stamp before assembly to engine.

6. Remove piston pin snap rings.

7. To facilitate the removal of piston pins, first heat pistons in hot water; then push pin from piston, using an arbor press or other suitable method. Do not drive or otherwise force pin from piston.

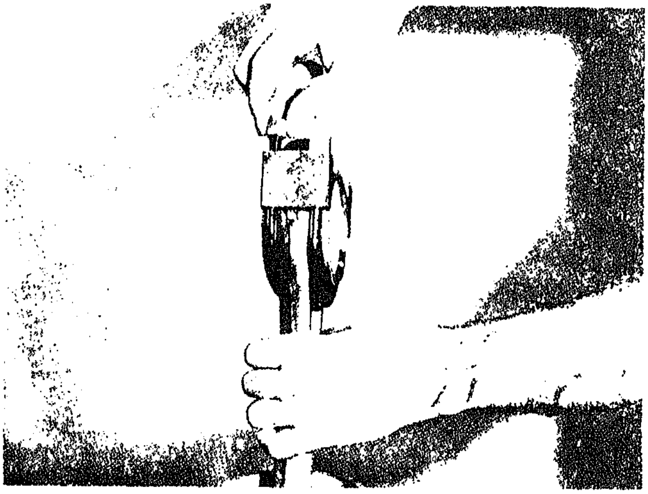


Fig. 0-54. Reassembling cap to connecting rod N20026

Fig. 0-56 [illegible] caps from block N2

Crankshaft and Main Bearing Caps

1. Turn engine so bottom side is up; loosen capscrews securing caps to block, leaving two/three threads engaged in block to pilot caps as they are removed.

2. Pry each cap loose with pry bar, Fig. 0-55; remove capscrews and lockplates and lift caps from block, Fig. 0-56.

   Note: Lower thrust rings are held in place with dowels on No. 7 main bearing cap. Upper thrust rings rest in chamfer on No. 7 main bearing bore in block. Be careful not to drop thrust rings, remove before lifting crankshaft.

3. Remove main bearing shells from crankshaft (if they did not adhere to caps).

4. Lift crankshaft from cylinder block, using hooks covered with rubber hose or a rope, to prevent bearing surfa damage, Fig. 0-57 remove upper main bearing shells.

5. Tape lower and upper main bearing shells together a identify according to cylinder number for future referen

1. Pull cylinder liners from block with Liner Pul using adapter plate.

   Note: The elevated top plate straddles the cylinder lin Fig. 0-58; the adapter plate, Fig. 0-59, is placed on bott of cylinder liner and held in place with a nut. When us the cylinder liner puller, be careful not to mutilate machin surface of cylinder block.

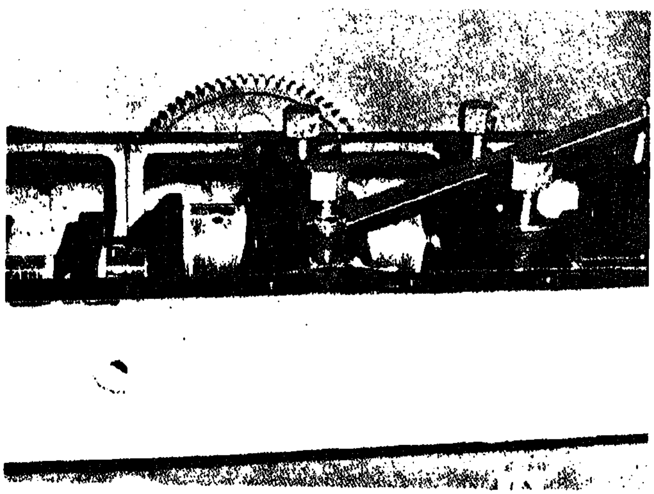
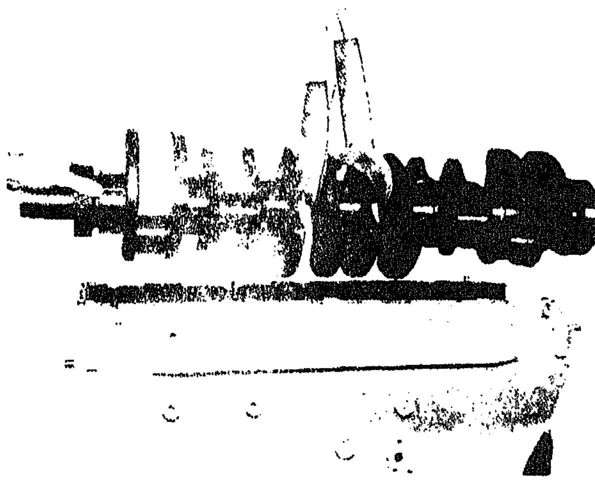


Fig. 0-55 Prying main bearing caps loose



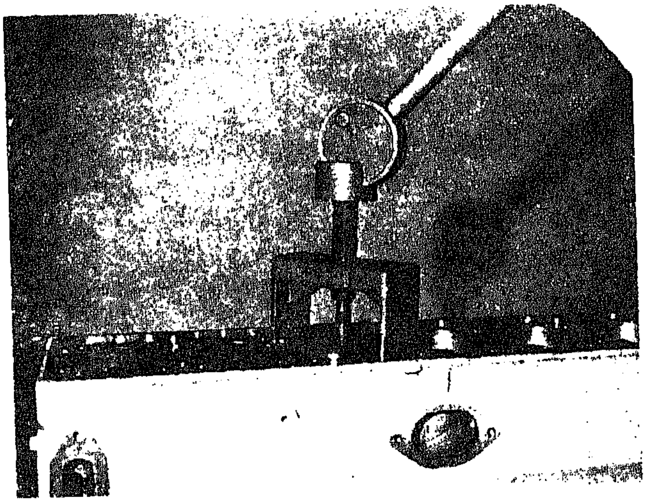


Fig. 0-58. Pulling liner with Liner Puller N20029

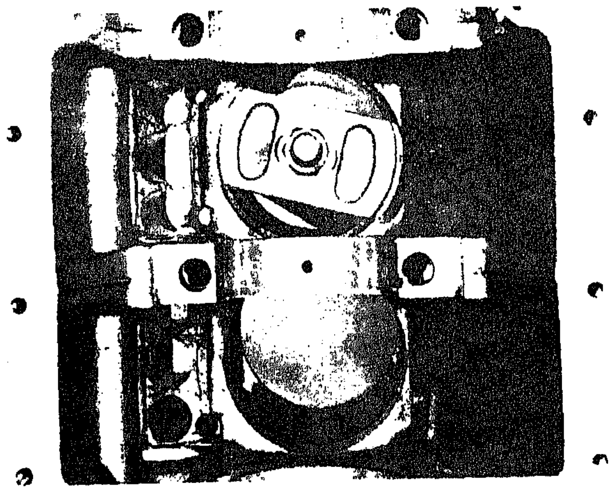


Fig. 0-59. Cylinder liner puller adapter plate N20062

2. Adjust shaft screw and pull down on cam lever to loosen liner. If liner sticks in block, turn lever in clockwise direction until liner is loose.
3. Remove liner puller and lift liner from block; remove and discard "O" rings and crevice seal (if used) from liner.

Steam Cleaning

1. Place parts in trays (except parts listed in following note) and clean with steam jet to remove exterior dirt, etc. Dry thoroughly with moisture-free compressed air.
2. Cover plates, pipe plugs, etc., should be removed as applicable to facilitate cleaning of oil and water passages.

Note: Do not steam clean the following:

a. Electrical components

b. Wiring

c. Injectors

d. Fuel pump

e. Belts and rubber hose

f. Bearing shells

Cylinder Block Group

The cylinder block group consists of cylinder block, cyl der liners, idler gear, crankshaft, bearing shells, damp counterbalancer, connecting rods, pistons, rear cover, ca shaft and gear cover. Cleaning, inspection and rebuildi of each part is described in this section.

Cylinder Block—Unit 101

Metric Measurement

all dimensions, temperatures, torque values, etc. are listed in both the U.S. and metric units of measurement. To aid in setting the two systems apart, the [Metric Units] are always enclosed in brackets.

Cleaning

1. Remove all pipe plugs from oil and water passages, etc.
2. Clean block by submerging in tank of cleaning solution heated to near boiling. follow manufacturer's recommendations as to use.

a. Circulate solvent to increase effectiveness.

b. To remove heavy deposits of lime, circulate acid-type cleaner.

Caution: The use of acid may be extremely dangerous to workmen and injurious to machinery. Never use in machine shop or near machinery subject to rusting. Always provide a tank of strong soda water as neutralizing agent.

Table 1-1-1: Cylinder Block Pipe Plug Torque

Plug Size	Minimum		Maximum	
In.	Ft.-lb.	[kg m]	Ft.-lb.	[kg m]
1/8	5	[0.6915]	15	[2.0745]
1/4	20	[2.7660]	25	[3.4575]
3/8	*25	[3.4575]	*35	[4.8405]
1/4	15	[2.0745]	20	[2.7660]
3/4	60	[8.2980]	70	[9.6810]

*3/8 in. N.P.T.F. above and on front camshaft side of block

Passages

1. Run rods with brushes or swabs through all oil passage Fig. 1-1-1.

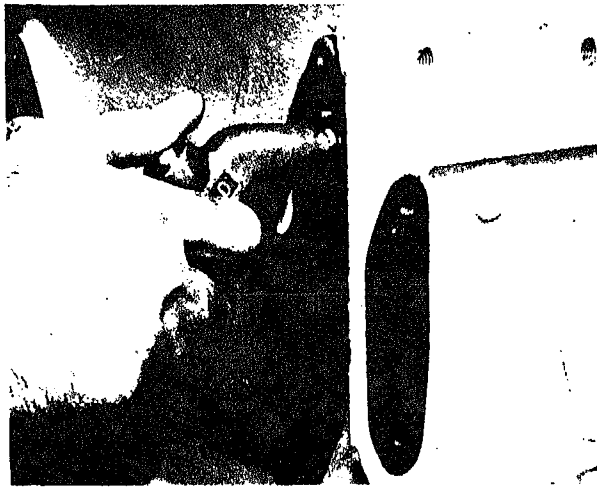


Fig. 1-1-1. Cleaning block oil passage N2

2. Replace all pipe plugs. Use "Teflon" sealing tape or Lead Sealer, No. 2" on plugs to prevent leaka Tighten plugs to values listed in Table 1-1-1.

Note: If additional machining is to be performed, oil p sage cleaning and replacement of plugs should be do after all machining is completed.

Air Vent Hole

Clean hole at front (No. 1 cylinder) that opens into wa

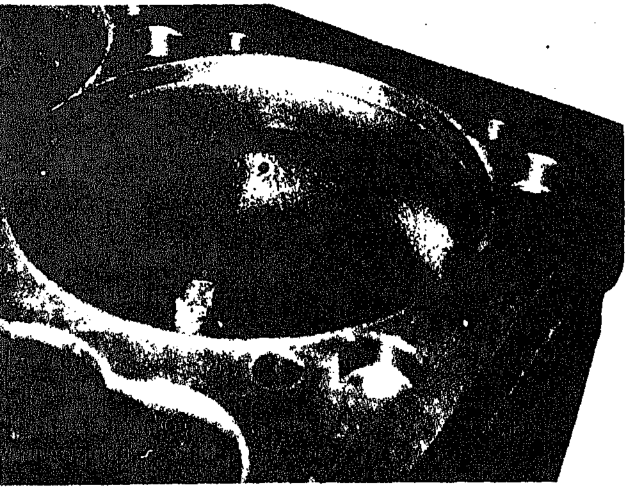


Fig. 1-1-2. Air bleed hole N20137

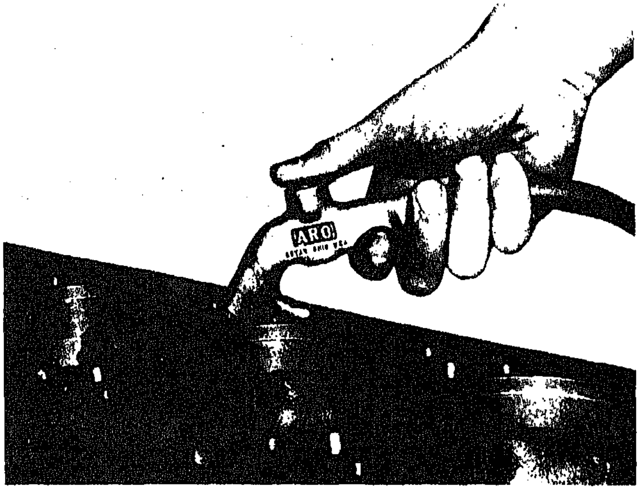


Fig. 1-1-3. Cleaning cylinder head capscrew hole N20138

Liner Bore

Scrape counterbore lightly to remove any scale.

Clean lower liner bore with sandpaper or sanding drum powered by an electric drill. Emery cloth may be used if bore contains ridges. Be sure to remove nicks or burrs that would damage liner packing rings as liner is installed.

Using Dye Penetrants To Locate Flaws

To successfully use dye penetrant method of locating cracks, porosity, leaks, etc. requires cleaning the part, penetrant application, developing the penetrant and inspection.

Clean suspected defective area with kerosene or other grease removing cleaner.

Apply dye penetrant allowing time for it to dissolve or enter into the defect (usually about fifteen minutes); do not "force" dry. Remove all excess penetrant.

Apply developer so defect will stand out; cracks usually show up as a solid or dotted line; however, caution must be observed as this can be a non-damaging forging lap.

Porosity usually shows up as dots in local areas. The wider the area spreads, the larger the defect.

Capscrew Holes

Blow all dirt or cleaning fluid from capscrew holes with an air jet, Fig. 1-1-3.

Caution: Anytime air jets are in use, the workman must

2. Cylinder head capscrew holes in block are counterbored to prevent distorting and forcing liners out-of-round, when cylinder head capscrews are tightened. All dirt and oil must be removed from holes to prevent damaging block when capscrews are tightened.

Inspection

Before any part is discarded or used again a careful inspection must be performed. The inspection should include wearing surfaces and general over-all conditions. Cost of rebuilding an engine can be high or low, depending entirely upon intelligent inspection and use of proper standards.

Corrosion

Corrosion most frequently occurs on portions of block nearest cylinder liners and is evidenced by pitting. Discard block if area cannot be cleaned, or if area is distorted.

Camshaft Bushings

1. Use inside micrometers or dial bore gauge to gauge camshaft bushing inside diameter, Fig. 1-1-4. Mark bushings for replacement if worn larger than "Worn Limit" shown in Table 1-1-2.
2. If bushings have been badly chipped, scored or scratched, mark for replacement.
3. If bushings have turned in block

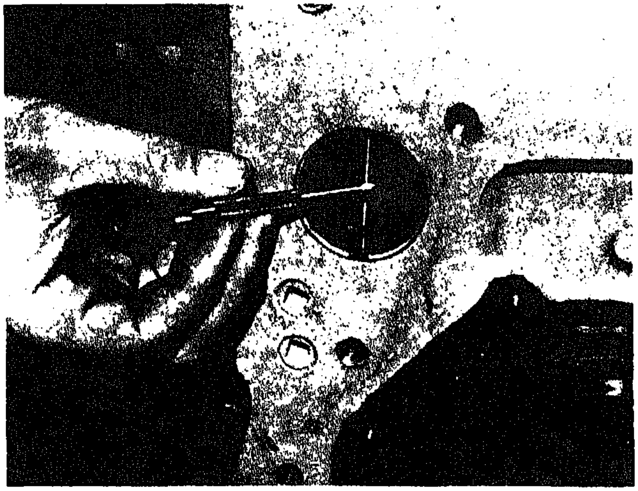


Fig. 1-1-4. Checking camshaft bushing inside diameter N20139

Table 1-1-2: Camshaft Bushing Inside Diameter

New Dimension Minimum		Maximum		Worn Limit	
In.	[mm]	In.	[mm]	In.	[mm]
1.8745	[47.6123]	1.8765	[47.6631]	1.8780	[47.7012]

Note: No. 1 bushing also serves as thrust plate and is attached to camshaft.

Table 1-1-3: Block Camshaft Bushing Bore

Bore No.	New Dimensions Minimum		Maximum		Worn Limit	
	In.	[mm]	In.	[mm]	In.	[mm]
2-7	2.0035	[50.8889]	2.0045	[50.9143]	2.0055	[50.9397]
1	2.1245	[53.9623]	2.1255	[53.9877]	2.1265	[54.0131]

4. Make certain oil passages in bushings and block are properly aligned. If bushing replacement is necessary, see "Parts Replacement and Repair"

Cylinder Liner Counterbore

1. Check upper liner counterbore diameter at four equidis points, Fig. 1-1-5. If counterbore exceeds limits shown Table 1-1-4 for the top 0.250 in. [6.3500 mm] depth, mar block for machining for oversize flange liners.

Caution: Do not attempt to rework counterbore inside meter on C engines.

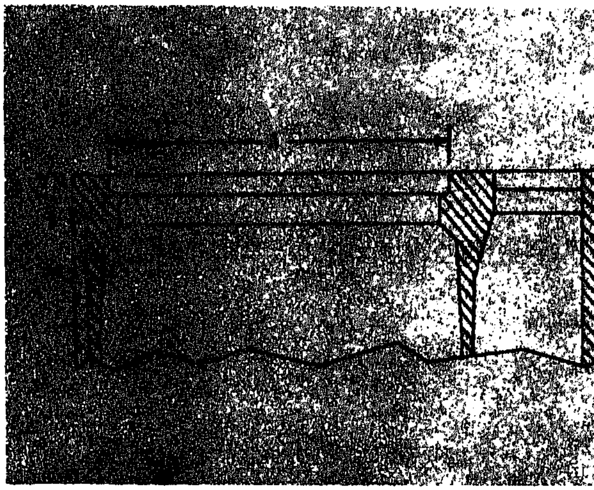


Fig. 1-1-5. Cylinder liner counterbore dimensions N2

2. The counterbore ledge must be smooth and perpendic to the cylinder liner bore.

3. Check counterbore depth so installed liner will be ass bled to correct protrusion and to determine if refinish counterbore surface is necessary. Depth of counterbore a new block is listed in Table 1-1-5.

Table 1-1-5: Cylinder Liner Counterbore Depth

New Dimensions Minimum		Maximum		Worn Limit	
In.	[mm]	In.	[mm]	In.	[mm]
0.3092	[7.8536]	0.3105	[7.8867]	0.4023	[10.21

Table 1-1-4: Cylinder Liner Counterbore Diameter

Engine Series	Bore Size		New Dimensions Minimum		Maximum	
	In.	[mm]	In.	[mm]	In.	[mm]
C	4 7/16	[112.7125]	5.187	[131.7498]	5.189	[131.8006]

f worn to or beyond worn limit the cylinder block must be eplaced.

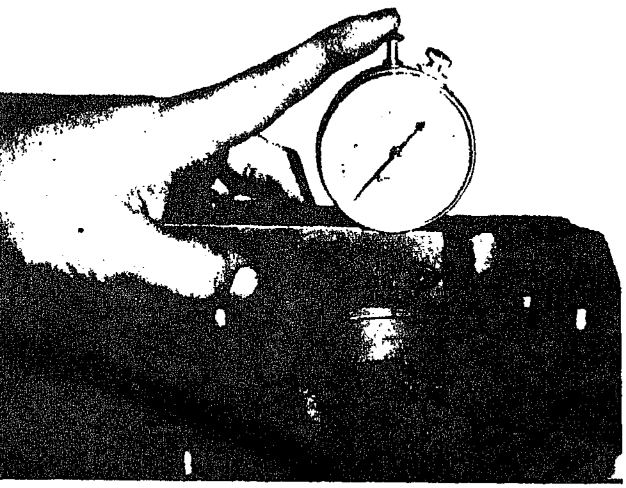
nstalled cylinder liners must protrude 0.004/0.006 in. 0.1016/0.1524 mm] above block. To check for proper pro- rusion without installing a liner:

Measure liner flange outside bead with micrometer, Fig. -1-6. **Do not include bead on top of liner flange in taking neasurement.**

ig. 1-1-6. Checking liner flange height — outside bead N20141

Measure block counterbore depth with dial indicator depth gauge or Gauge Block, Fig. 1-1-7. 'zero" indicator before taking measurement.

Check depth at four equidistant locations. Ledge must not



ig. 1-1-7. Checking liner counterbore depth in block N20142

be "cupped" more than 0.0007 in. [0.0177 mm]. Depth must not vary more than 0.001 in. [0.254 mm] throughout counterbore circumference.

d. If dimensions do not meet standards of step "C" above, counterbore must be resurfaced. See "Parts Replacement and Repair."

e. Subtract counterbore depth from liner flange thickness to determine amount of shims and depth of counterbore cut that must be used to provide desired liner protrusion (see "5" above). 0.007 in. [0.1778 mm] shims are thinnest available.

Note: If material to be removed will result in a counterbore depth exceeding worn limit in Table 1-1-5, block cannot be reused.

Cylinder Liner Lower Bore

1. Install a new cylinder liner in the block without packing rings or crevice seal.

   Note: Liner contact is permissible as long as it does not cause liner out-of-round.

2. Clearance between liner and block should be as shown in Fig. 1-1-8 and listed in Table 1-1-6.

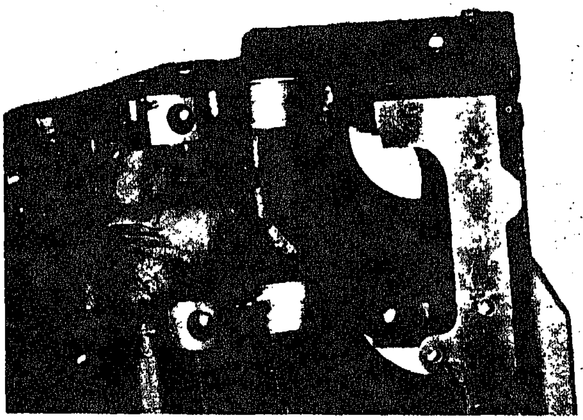


Fig. 1-1-8. Checking clearance between block and liner N20113

Table 1-1-6: Liner-To-Block Clearance Lower Bore

Minimum		Maximum	
In.	[mm]	In.	[mm]
0.005	[0.1270]	0.009	[0.2286]

3. If clearances do not fall within above limits, recheck after counterboring.

Note: These limits do not apply with cylinder head installed and tightened to operating torque.

4. If clearance is not correct, check lower block packing ring bore inside diameter. See Table 1-1-7.

Table 1-1-7: Lower Liner Bore Inside Diameter

Engine Series	Bore In.	[mm]	Minimum In.	[mm]	Maximum In.	[mm]
C	4 7/16	[112.7125]	4.933	[125.2982]	4.935	[125.3490]

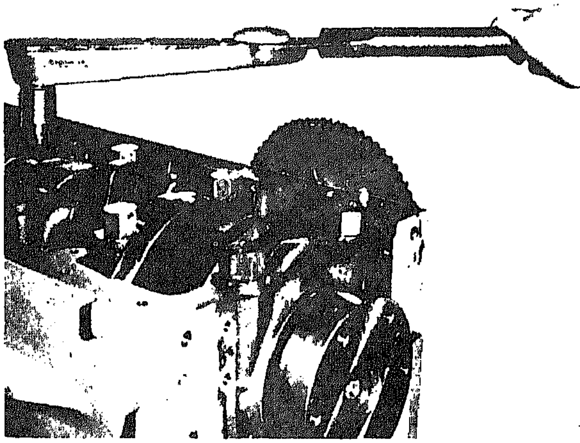


Fig. 1-1-9. Tighten main bearing capscrews N2

Main Bearing Caps

1. Main bearing caps have an interference fit to block of 0.002/0.004 in. [0.0508/0.1016 mm].
2. Caps must fit in block with no perceptible clearance or "shake". Milled faces of cap must always rest on mating portion of block to prevent distortion during tightening.
3. Replacement caps, which must be machined to fit, are available as service parts; see "Parts Replacement and Repair"

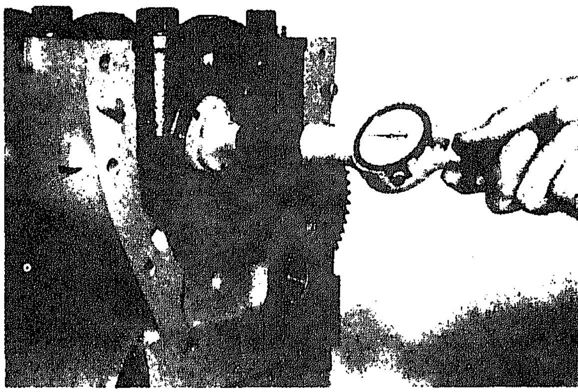


Fig. 1-1-10. Checking main bearing bore for out-of-round N

Main Bearing Bore

1. Assemble main bearing caps, lockplates or flatwashers and capscrews to block in operating position, Fig. 1-1-9. Tighten capscrews to operating tension; see "Parts Replacement and Repair"
2. Gauge main bearing bores horizontally, vertically and diagonally with dial bore gauge or inside micrometers properly adjusted to standards, Fig. 1-1-10. See Table 1-1-8.

Table 1-1-8: Main Bearing Bore

New Dimensions Minimum In.	[mm]	Maximum In.	[mm]	Worn Limit In.	[mm]
4.1240	[104.7496]	4.1250	[104.7750]	4.1255	[104.7877]

3. Check bore alignment This closely ground bar will pass through all bores and turn fre ly unless caps are not tightened to proper tension, burrs, etc., have not been removed, or caps are distorted, Fig. 1-1-11.

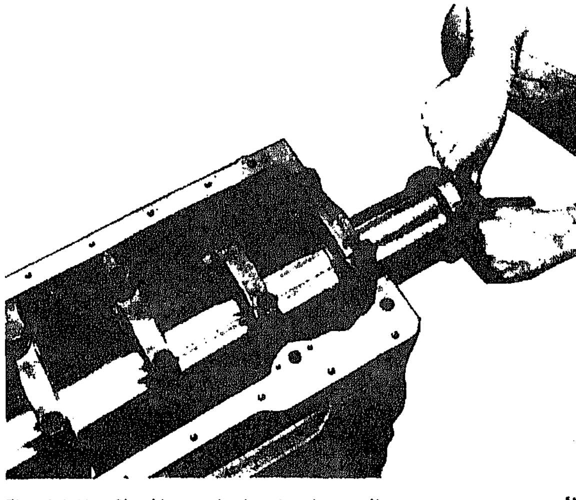


Fig. 1-1-11. Checking main bearing bore alignment N

If it is definitely determined that a main bearing cap has been distorted and is preventing checking bar from passing through bore, mark block for reaming.

Water Passages

Check all water passages to make sure they are open.

Check for eroded water holes which may prevent proper seating of head gasket or grommet retainers.

Water holes not eroded more than $\frac{1}{16}$ in. [1.5875 mm] from edge of hole can be "bushed"; see "Parts Replacement and Repair"

Check for erosion within $\frac{1}{32}$ to $\frac{3}{32}$ in. [0.7937/2.3812 mm] from liner counterbore; if not too deep block may be resurfaced.

Tappet Bores

Measure tappet bores with a dial bore gauge, Fig. 1-1-12. See Table 1-1-9.

Table 1-1-9: Tappet Bore Size

Tappet Location	New Dimension Minimum In.	[mm]	Maximum In.	[mm]	Worn Limit In.	[mm]
Injector	1.3120	[33.3248]	1.3130	[33.3502]	1.3145	[33.3883]
Valve	1.1870	[30.1498]	1.1880	[30.1752]	1.1895	[30.2133]

If worn beyond limit in Table 1-1-9 or out-of-round more than 0.0015 in. [0.0381 mm], replace block.

Idler Gear Shaft

On supercharged engines, replace idler shaft if worn smaller than 1.4995 in. [38.0873 mm] diameter.

Tighten idler shaft capscrews to 200 to 204 in.-lbs. [2.3000 to 2.3460 kg m] torque.

Parts Replacement And Repair

After a thorough inspection of cylinder block, bushings and main bearing caps, the decision must be made whether to install a new block assembly, replace bushings or caps and how much can be done to rebuild or recondition the

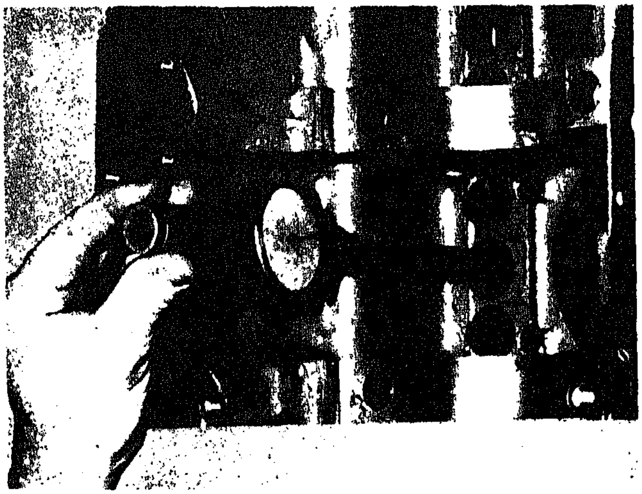


Fig. 1-1-12. Checking tappet bore inside diameter N20135

reusable parts. The following instructions cover the operations that may be performed to make a reusable block ready for service.

Camshaft Bushing Replacement

1. Service tools are available for removal and installation of camshaft bushings. The tool consists of two parts, Bushing Driver and Bushing Mandrel.
2. No. 1, or gear case end, camshaft bushing also acts as the camshaft thrust plate and is attached to the camshaft.
3. Locate bushing on drive mandrel and align oil holes in bushing with those in block.
4. Drive in position so oil holes are aligned, Fig. 1-1-13.

Main Bearing Cap Replacement

1. Semi-finished replacement main bearing caps are available for limited use in rebuild shops.

   Note: The responsibility for use of semi-finished caps must be assumed by the engine owner or by the shop which performs the work.

2. Replacement main bearing caps have 0.003 in. [0.0762 mm] material in bore and 0.005 in. [0.1270 mm] excess in length (pilot dimension). Other dimensions are the same as finished main bearing caps.
3. A No. 7 new replacement cap does not have cap-to-block dowel holes and must be ma-

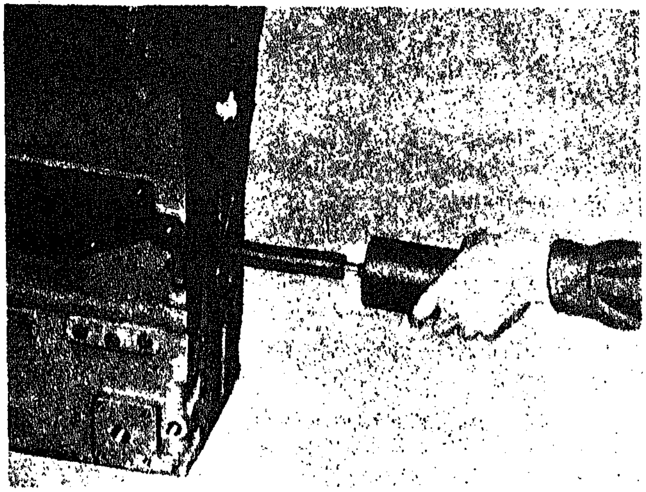


Fig. 1-1-13. Installing camshaft bushing N20112

chined to block width.

4. Machine an equal amount of material from each end of semi-finished cap to provide 0.002/0.004 in. [0.0508/0.1016 mm] interference fit in block.

5. If the cap is a rear cap (No. 7 or No. 5):

a. Remove locating dowels from block.

b. Locate and machine cap so thrust faces of cap and block are flush. Use Prussion Blue on block surface to locate dowel holes in cap.

c. Remove cap.

d. Drill dowel holes, Fig. 1-1-14.

e. Reinstall cap and ream dowel holes to the smallest permissible oversize.

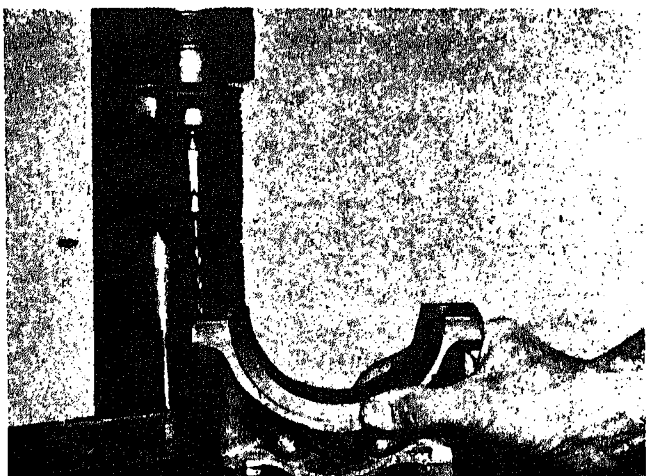


Fig. 1-1-14. Drilling dowel hole in rear main bearing cap N20144

f. Install dowels in block.

6. Install all caps on block and ream bore as describe following paragraphs.

Main Bearing Bore Reaming

1. If main bearing bore was out of alignment or if rep ment cap has been installed ream bore as follows.

Caution: Do not ream the main bearing bore indis nately. It should never be necessary to ream the main unless a cap has been distorted or replaced. Use o reamer must never replace use of the checking bar.

2. If bore must be reamed, first remove 0.002/0.003 in. [0. 0.0762 mm] stock from bottom milled surface of main ing caps which are out of alignment. Remove stock b ping or surface grinding.

Note: Omit this step if replacement caps are being u

3. Lay Reaming Bar in block so rear of bar is pi in two good main bearing bores.

4. Install all main bearing caps in block and tighten screws to operating tension, following steps show Table 1-1-10, in alternating steps from one capscrew t other on same journal.

5. Lubricate reamer cutters and bores in block with e lubricating oil. This will prevent reaming oversize an allow a better finish, Fig. 1-1-15.

6. Use Hand Driver to turn the reamer, Fig. 1 This driver is loosely pinned to prevent up and dov side thrust of reamer while it is being turned.

7. Run reamer through remaining main bearing bores wi "backing up" or reversing.

8. Check bore with Checking Bar and measure bore dia once again with dial bore gauge. See Figs. 1-1-10 1-1-11, and "Main Bearing Bore".

9. Clean block thoroughly.

Sleeve Eroded Water Holes

The cylinder block surfaces around the water holes be free of any erosion, pits, scratches or blemishes are more than 0.003 in. [0.0762 mm] deep in the area 5/32 in. [1.5875 to 3.9674 mm] from edge of water holes pair as follows:

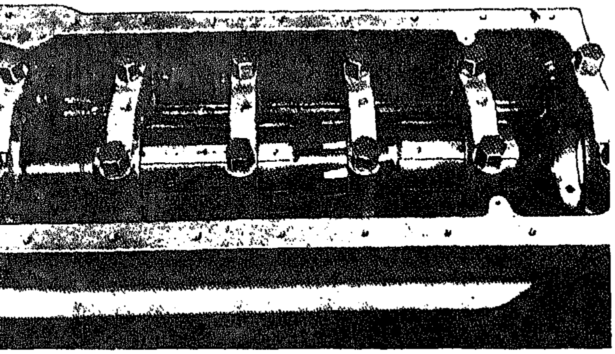
1. Insert hold-down adapter of into cylinder capscrew hole, Fig. 1-1-16.

2. Position tool on head with reamer guide hole over hole to be repaired.

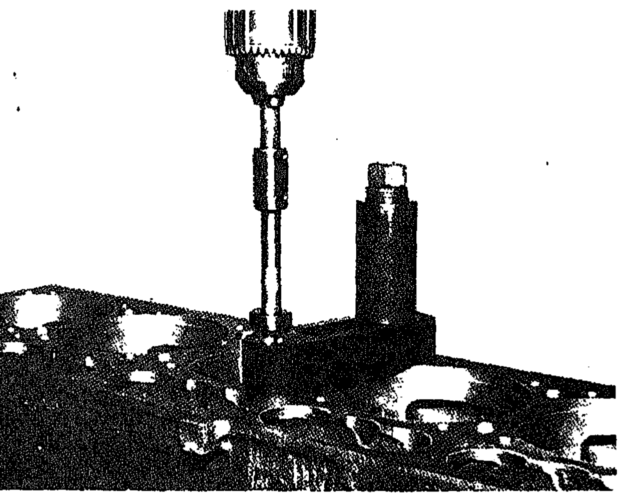
3. Insert tool hold-down knob into holder assembly and en down finger tight.

able 1-1-10: Main Bearing Capscrew Tightening

tep	Ft. Lbs.	[Kg m]
. Tighten to	65/75	[8.9895/10.3725]
. Advance to	140/150	[19.3620/20.7450]
. Loosen	ALL	ALL
. Tighten to	45/50	[6.2235/6.9150]
. Advance	60°	60°



ig. 1-1-15. Reaming main bearing bore N20110



ig. 1-1-16. Reaming eroded water hole N20145

nsert locating pin into eroded hole and tighten hold-down nob.

o set depth of reamer assembly, insert assembly in guide. Place bushing between holder assembly and reamer adjustable stop collar. Insert 0.005 in. [0.1270 mm] feeler gauge between bushing and adjustable collar; tighten setscrew.

Caution: Take care not to use too large a reamer, avoid getting head gasket grommet over liner flange.

6. Attach drive adapter to half-inch drill chuck and place grooved end of drive adapter into reamer assembly.

7. Ream out eroded water hole until collar bottoms against tool.

8. Remove drill, reamer assembly, holder assembly and hold-down adapter.

9. Drive bushing into reamed hole with driver. Bushing should protrude about 0.003 to 0.005 in. [0.0762/0.1270 mm].

10. If block is to be resurfaced, see "Resurface Cylinder Block". If not to be resurfaced, file bushing flush with head, using a wide, flat mill file.

Top Surface Refinishing

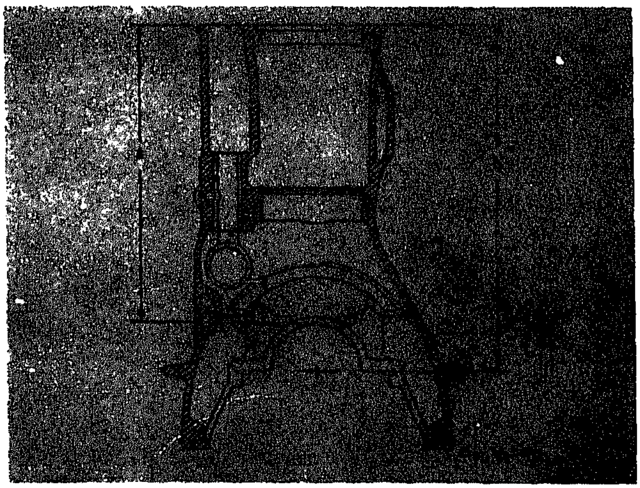
Under certain conditions, a cylinder block may be salvaged by removing a maximum of 0.010 in. [0.2540 mm] of material from the top surface.

1. Use either a milling machine or large surface grinder; locate block on main bearing pads, **not on pan ledge.**

2. Make light cuts of 0.001/0.003 in. [0.0254/0.0762 mm] deep, removing only enough material to make block usable.

3. Check distance from centerline of main bearing bore to top of block, Figs. 1-1-17 and 1-1-18.

a. Find this dimension by placing block, top down, on a flat surface plate and measuring from main bearing bore centerline to plate, Table 1-1-11.



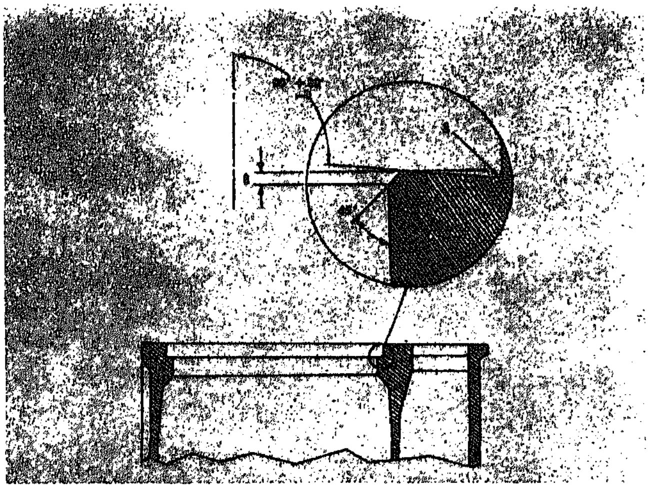


Fig. 1-1-18. Cylinder liner counterbore cross section N20147

b. An alternate method is to check distance from installed main bearing bore alignment bar to top surface of block, Table 1-1-12.

c Distance from head surface to main bearing bore centerline must not vary more than 0.002 in. [0.0508 mm] throughout length of block. Head surface flatness must not vary over 0.002 in. [0.0508 mm].

Table 1-1-11: Cylinder Block Height From Main Bearing Centerline (B, Fig. 1-1-17)

New Dimensions Minimum		Maximum		Worn Limit	
In.	**[mm]**	**In.**	**[mm]**	**In.**	**[mm]**
15.122	[384.0988]	15.124	[384.1496]	15.114	[383.8956]

Table 1-1-12: Cylinder Block Height From Alignment Bar (A, Fig.1-1-17)

New Dimensions Minimum		Maximum		Worn Limit	
In.	**[mm]**	**In.**	**[mm]**	**In.**	**[mm]**
13.0600	[331.7240]	13.0615	[331.7621]	13.0500	[331.4700]

4. Finish surfaces to 125 R.M.S.

Note:

this operation can be done only

5. Resurface counterbore to obtain proper liner protrusi

Cylinder Liner Counterbore

Resurface cylinder liner counterbore if block has beer surfaced, ledge is uneven or where liner protrusion is correct. Counterbore Tool with appropriate ada plate is used for this operation.

1. Use Adapter Plate for C engines

2. Check counterbore tool bit before boring operation.

a. A correctly ground tool bit will leave counterbore sur complete flat or cupped to a 30-minute angle (the cu preferred) with a 0.005/0.015 in. [0.1270/0.3810 mm] ra as shown in (A Fig. 1-1-18).

b. A correctly ground tool bit is shown in Fig. 1-1-19. Poi is 0.008/0.012 in. [0.2032/0.3048 mm] radius; side sur must be ground flat to sharpen.

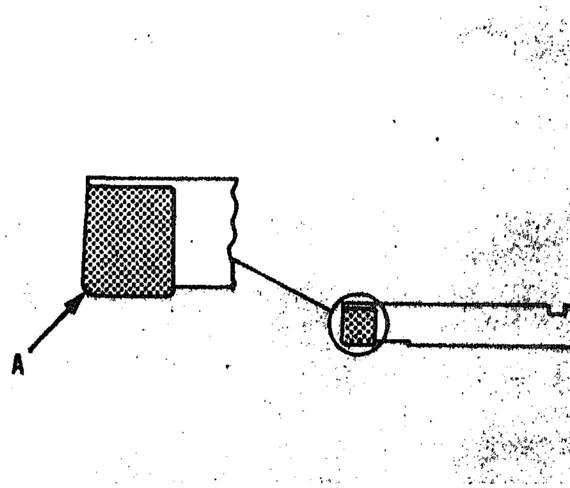


Fig. 1-1-19. Counterboring tool bit specifications N

3. Position tool adapter in liner bore.

4. Tighten top and bottom locating pins by turning in soc head screws.

5. Set tool adjustable sleeve so blade just touches bottor counterbore ledge. Use lubricating oil on cutter blade

6. Turn tool in clockwise rotation with even pressure.

Caution: Never turn tool counterclockwise. Doing so damage cutter blade.

7. *Use a series of light cuts to clean up entire circumfere of seat.*

Caution: Under no circumstances may inside diameter of ledge be lower than outside diameter. A ledge that droops toward center could contribute to cylinder liner breakage. Maximum counterbore depth after boring must not exceed limit given in Table 1-1-5.

Chamfer edge of counterbore ledge 45 degrees after counterboring. See (B Fig. 1-1-18). Do not chamfer deeper than 0.002/0.005 in. [0.0508/0.1270 mm]

avoid reducing liner seating area.

Use shims to compensate for metal removed and to restore liner protrusion to 0.004/0.006 in. [0.1016/0.1524 mm]. Shims are available as shown in Table 1-1-13.

Note: Use as few shims as possible, i.e., use one thick shim in preference to two or more thinner shims. Never use shims thinner than those listed.

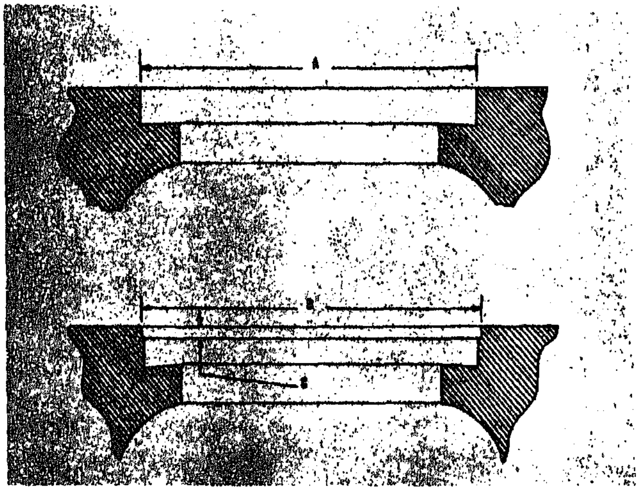


Fig. 1-1-20. Standard and oversize counterbore diameters N20149

Oversize Cylinder Liner Counterbore

Enlarge block counterbore diameter to 4.894/4.896 in. [124.3076/124.3584 mm] (B, Fig. 1-1-20) with a vertical boring bar or equivalent. Non-press-fit liner bore (A, Fig. 1-1-20) was 4.874/4.876 in. [123.7996/123.8504 mm].

Extend cut to only 0.200/0.250 in. [5.0800/6.3500 mm] (C, Fig. 1-1-20) below surface of block.

Caution: Do not extend cut full depth of counterbore or liner shims will not locate correctly.

Remove sharp corners and burrs.

Use shims as listed in Table 1-1-13 as necessary during liner assembly.

Cylinder Head Capscrew Threads

Check cylinder head capscrew hole threads in block. If threads are damaged, block may be repaired by installing Heli-coil inserts.

1. 3/4 In. [19.0500 mm] cylinder head capscrews.

a. Drill out old threads with 13/16 in. [20.6375 mm] drill to 1 15/16 in. [49.2125 mm] depth.

b. Rough and finish tap drilled hole with tap from ST-595 to 1 19/32 in. [40.4812 mm] depth.

c. Install insert, with inserting tool. Break off notched lead tang of insert.

2. Paint outside of cylinder block with engine paint.

Table 1-1-13: Cylinder Liner Counterbore Shims

Thickness In.	[mm]	Part No. C
0.0063/0.0077	[0.1600/0.1955]	124107
0.0072/0.0088	[0.1828/0.2235]	124108
0.0081/0.0099	[0.2057/0.2514]	124109
0.018/0.022	[0.4572/0.5588]	124110
0.028/0.034	[0.7112/0.8636]	124111

Cylinder Liners—Unit 102

Cleaning And Inspection

1. Remove rust and scale from liner exterior with wire brush or by similar cleaning operation.
2. Check for cracks in cylinder liners just under top flange, at bottom of liner, or above top seal ring groove. Check by:

a. Magnetize liner if magnetic equipment is available.

b. Pour magnetic solution over liner while it is still magnetized.

Note: Cast iron will not hold magnetism permanently.

c. If magnetic inspection cannot be performed, clean liner thoroughly.

d. Spray suspected area with dye penetrant.

e. Allow penetrant to dry for fifteen minutes. Do not "force" dry; remove excess dye.

f. Spray with developer and check for crack indications. See Page 1-1-2, "cracks".

3. Discard any liner with excessive corrosion or erosion and pits $\frac{1}{16}$ in. [1.5875 mm] deep or more.
4. Check underside of liner flange for dents, pitting or fretting. Discard liner if any unevenness cannot be removed by lapping.
5. Check worn liners with dial bore gauge, Fig. 1-2-1. If liners are worn more than 0.004 in. [0.1016 mm] in excess of new liner maximum diameter, replace or hone to next oversize. See Table 1-2-1 for new-liner dimensions. Pistons for oversize liners are available in 0.020, 0.030 and 0.040 in. [0.5080, 0.7620 and 1.0160 mm] oversizes.

Table 1-2-1: Std. Cylinder Liner Inside Diameter—In. [mm]

Engine Series	Liner Material	New Dimensions Minimum	Maximum	Worn Limit
C	Cast Iron	4.4370 [112.6998]	4.4380 [112.7252]	4.4420 [112.8268]

Note: Dimensions at 60/70° F. [15.6/21.1° C.]; new liners with lubrite finish may be 0.0002/0.0006 in. [0.0050/0.0152 mm] smaller than indicated due to lubrite coating.

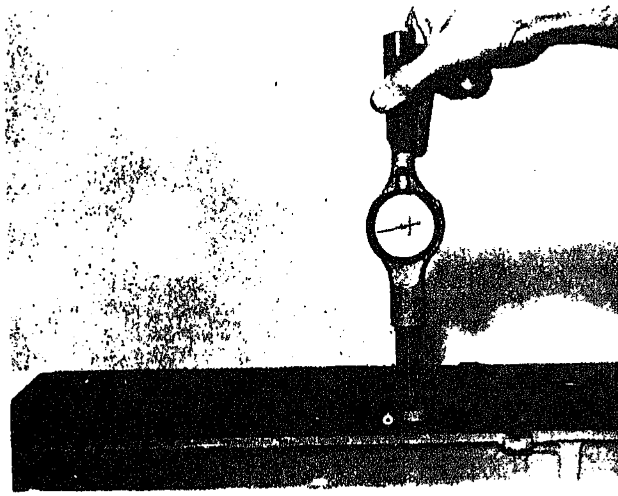


Fig. 1-2-1. Measuring liner bore N201

6. Mark liners to be reused for ridge cutting, boring or grin ing and honing if worn less than above limits and othe wise undamaged in area (1, Fig. 1-2-2).

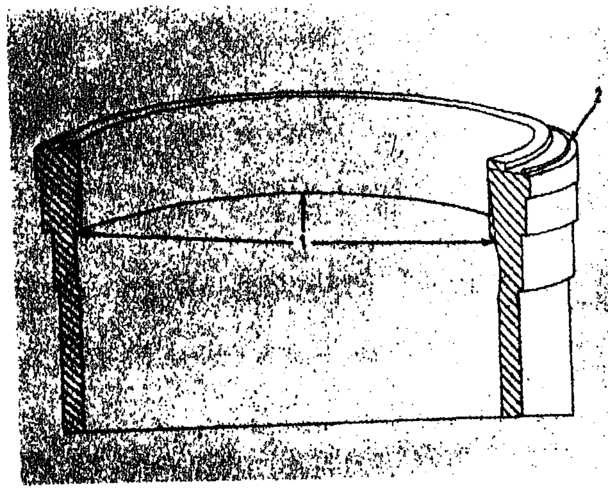


Fig. 1-2-2. Worn ridge in cylinder liners N2

Grind Cylinder Liners

Cylinder liners should not be reused without reboring

regrinding if they exceed worn limits. Pistons and rings are available in 0.020, 0.030, 0.040 in. [0.5080, 0.7620 and 1.0160 mm] oversizes. Add oversize increments to standard dimensions to determine final oversize dimension desired.

Remove ridge at top of worn liners with a ridge cutter, or other means, to prevent damage to new rings.

Grind or bore liners to next standard oversize.

Finish hone liners to proper finish. See "Liner Honing".

Liner Honing

Honing operation described below is not designed to enlarge cylinder bore several thousandths [millimeters] for oversize pistons and rings. When honing oversize, both roughing and finishing stones are used. Recommendations given are specifically designed to put proper finish and geometric design in cylinder liner with a minimum of stock removal. For this reason, only one grit size is used and stones are used wet.

Walls can be straightened with 4 or 5 final passes through bore. Proper finish will be on walls due to fine grading of stone recommended. Visual inspection of liner honed, according to recommendations, will indicate importance of using equipment and procedures which give the operator maximum control of operation.

Initial Set-up

Place cylinder liner in cylinder bore of a scrap block without packing rings or crevice seal. Upper liner bore in block should be relieved so liner will drop into place very easily.

Tap two water holes and assemble capscrews and soft washers to holes making sure soft washers are over liner flange, but do not extend into bore of liner. Tighten finger tight and make an initial check for distortion on the new fixture as follows:

Place dial gauge in cylinder liner about 1½ in. [38.1000 mm] from top.

Watch gauge for movement while capscrews are tightened to secure liner.

Loosen capscrews and move dial bore gauge to another position in liner bore and repeat check while tightening capscrews.

If distortion is noted, remove liner and check for dirt between flange and counterbore ledge. Also, check flatness of counterbore ledge. If liner is seating evenly on ledge, distortion will be less than 0.0003 in. [0.0076 mm] and barely noticeable.

Assemble a Honing Stand to cylinder block. Use wooden blocks to adapt base to bore size; then use expanding foot to tighten base to stand in bore.

4. Assemble upper support arm to stand and attach drill handle to canvas loop.

5. Place a Quick Coupler, securely in drill chuck, Fig. 1-2-3.

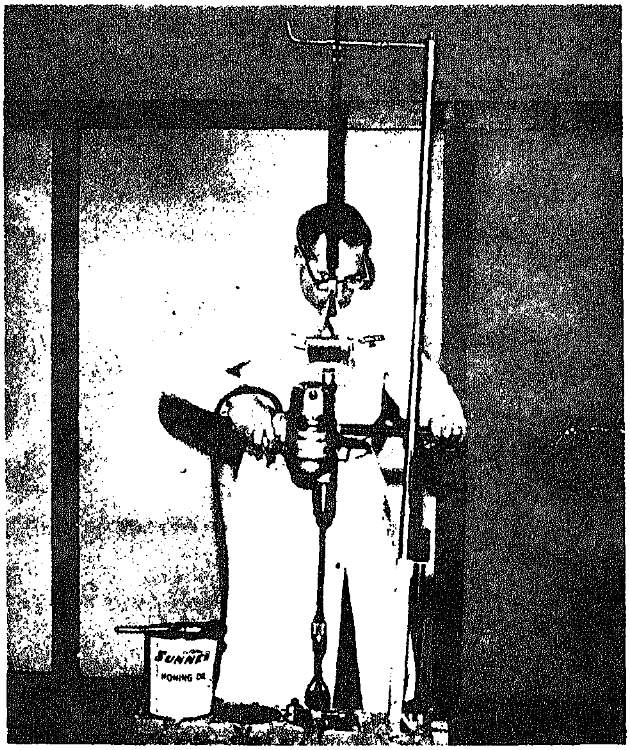


Fig. 1-2-3. Honing liner N20152

6. When installing Coarse Finishing Stone Set carefully note manufacturer's instructions concerning their assembly to Cylinder Hone and suggested use.

7. Insert hone assembly into top of cylinder liner. Raise center pinion (knurled nut) assembly ¼ in. [6.3500 mm] and turn counterclockwise (left) to expand stones to approximate bore size, Fig. 1-2-4. Push center pinion down until its inside gear engages outside gear on hone body. Attach hone to quick coupler.

8. Swing upper support arm so drill and hone are approximately over center of liner bore. Adjust length of canvas

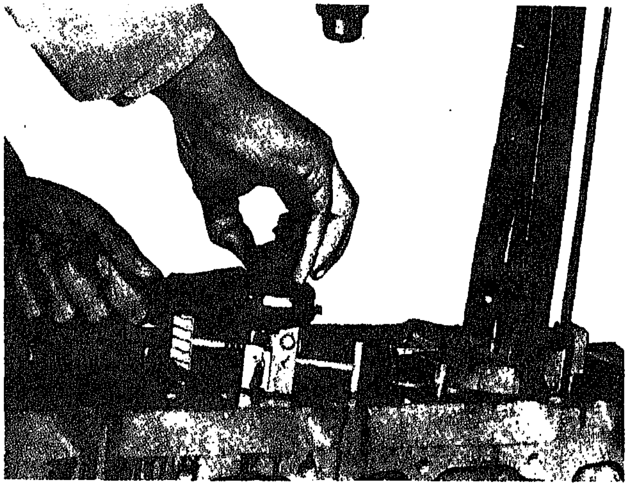


Fig. 1-2-4. Initial stone expansion V10131

strap attached to drill so hone hangs with ends of stones extending out of liner bore approximately 1 in. [25.4000 mm].

9. Adjust stroking stop (collar and wing screw) so stones will not extend more than 1 in. [25.4000 mm] from bottom of cylinder liner at end of down stroke. Put enough down pressure on hone to make sure they will not hit obstructions beneath liner during honing. Secure stop collar when setting is correct to clear stones.

10. Do not start drill motor. Practice stroke a few times for "feel" with stones expanded loosely in liner and not in actual contact with walls. Down stroke hits stop, but operator must stop stroke at top allowing stones to extend out top of bore ½ in. [12.7000 mm] to 1 in. [25.4000 mm]. Stroking speed required to produce a 35° to 45° crosshatch is approximately 50 strokes per minute, Fig. 1-2-5.

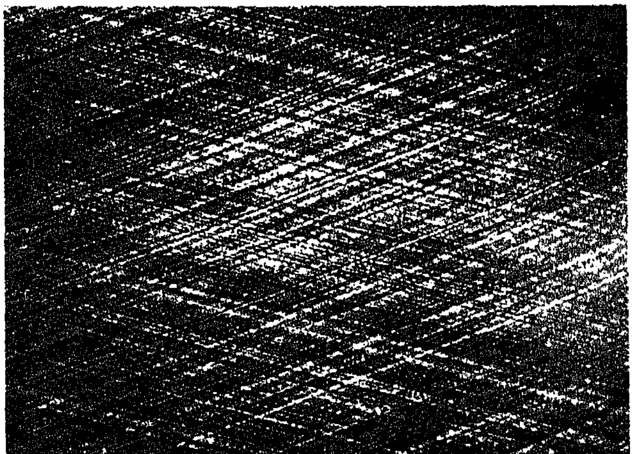


Fig. 1-2-5. Cylinder liner cross-hatch pattern N20153

Note: It is very important to have a 45° crosshatch patt to enable the piston rings to shear or peel the sharp ric points during break-in. If pattern is nearly horizontal so pattern engagement and tearing may occur. If pattern vertical, this forms a path for blow-by.

11. Disconnect hone and remove from liner.

12. The edges and corners of new stones are very sharp. Ta a hand hone and slightly round all corners and edges reduce tendency to crumble when stones are first used

13. Re-check set-up and become familiar with hone mechani and stroke. Check manufacturer's instructions packag with components.

Honing Operation

1. Check liner in honing fixture to make sure it is secure.

2. Check liner with dial bore gauge to determine how we pattern must be removed. In this case, assume that lir has a slight ring at top, 0.002 in. [0.0508 mm] wear a out-of-roundness in ring travel area. It tapers in at bott of bore due to lack of wear in that area.

3. Assemble hone to liner bore. Expand stones to diameter cylinder bore with quick-acting center pinion assem (knurled nut) as described under "Set-Up".

4. Expand stones and guides firmly against cylinder walls turning winged collar clockwise on top of pinion assemb Do not tighten too tight.

5. Apply Honing Oil freely to stones, guic and cylinder walls with brush or oil can after attachi hone to Quick Coupler.

6. Grasp drill handles (Heavy Duty drill with a 300 rpm no-load speed) firmly and tu on motor. Let extension handle contact vertical stand absorb torque of motor. Use hand on handle (with switc to keep drill and hone over center of liner.

7. Stroke as follows: Move to bottom of bore and bring ho up half-way in bore. Then go back to bottom of bore. next upstroke come all the way to top (don't let stones e tend more than ½/1 in. [12.7000/25.4000 mm] out top bore) and return to bottom repeating double stroke in b tom of bore. After 6 to 8 strokes have been made to top bore, double stroke both top and bottom of bore. T action removes stock faster at opposite ends of bore moving tapered condition of liner. The first honing cy should last only 10/15 seconds; then shut off drill a check for results. At first it may be wise to remove hc and check with dial bore gauge to become familiar w cutting speed of stones. Make a visual inspection of bc frequently and add oil to keep stones clean and cutt freely.

8. Apply oil and operate for another 10/15-second cycle needed, double stroking either end that is smaller in ameter than ring area. This operation is designed straighten wall of bore and remove carbon ring at t

:eep stones cutting by adjusting pressure with winged col-ar. A slight reduction in drill speed will be noted when tones are cutting. Torque action felt on drill handles also s a good indicator.

hirty to forty seconds honing time can remove 0.001/0.002 ı. [0.0254/0.0508 mm] from bore depending upon stone ressure. Straighten bore quickly by double stroking; then ull stroke bore only enough to lay a uniform finish on the valls. The total honing time will usually run about 20/40 econds to perform what is commonly called a deglazing peration.

\fter pattern is uniform, stop hone; adjust stones to a firm out light pressure. Apply oil and make 4 or 5 full-length trokes and shut drill off while continuing stroke. Double troke in bottom if necessary to time actual stopping of ıone rotation when hone is at top of bore. This preserves :ross-hatch pattern, and puts true stone pattern (20/30 rms inish) on cylinder walls, Fig. 1-2-5.

Rms is a convenient abbreviation for root mean square, a nathematical term indicating the average irregularity of urface.

This slightly irregular surface on the cylinder liners is re-quired so new piston rings and reworked liners will break n (or wear in) together.

t is also necessary to have basic honed pattern in liners o retain some oil in valleys as piston rings scrape away il on liner walls. If walls were smooth, they would quickly un dry and score.

Remove hone from liner and remove liner from fixture.

Make a final check of bore size and make sure that carbon ing at top and thrust wear pattern are removed. Note angle of cross-hatch to check stroke speed. Refer to Table 1-2-1 or specifications concerning maximum bore size. Out-of-oundness should not exceed 0.0015 in. [0.0279 mm] ex-cept at assembly as noted under "Assembly Group 14". If stones have been kept wet, walls will show a uniform satin inish and will be of proper 20/30 rms finish. If a smooth, shiny finish is noted, it is probably due to lack of oil, or motoring hone too long in final honing cycle. As oil dis-appears from walls, stones tend to load and become dull. Honing oil keeps stones sharp and promotes true cutting action.

Cleaning

After liners are honed, they must be cleaned thoroughly with solvent, steam cleaner or hot soap and water. It is recommended that cleaning operation be ended by scrub-bing bore with a bristle brush to remove as much honing debris as possible. Blow liners dry with compressed air.

Coat bore of liners generously with clean lubricating oil. If possible, let liners stand 5 or 10 minutes before next step.

bores. Note gray and even black residue that appears with oil on white towels. This is honing debris that remained on liner walls. Repeat application of lubricating oil and wipe off with white paper towels. If honing debris is still pres-ent, repeat lubricating oil treatment. Usually liners will ap-pear clean on second application. Liners must be com-pletely cleaned after honing. After soap and hot water treatment, liners will appear clean when a paper towel is wiped through dry bore. This is a false indication since lubricating oil treatment will remove additional abrasive material. We cannot be too emphatic about importance of thoroughly cleaning liners after honing.

Note: Always install new liner packing rings and crevice seals (as used) when assembling liner to engine.

Idler Gear—Unit 103

Cleaning And Inspection

1. Clean gears or assemblies in cleaning solvent.
2. Check ball bearing-equipped gears for worn or rough-running bearings.
3. Check bushings in idler gears to the dimensions in Table 1-3-1.
4. Check gears for worn, broken or cracked teeth. Mark for replacement as necessary.

Table 1-3-1: Idler Gear Bushings — In. [mm]

Engine Series	Location	New Dimensions Minimum	Maximum	Worn Limit
C-180	Gear Bushing	2.125 [53.9750]	2.126 [54.0004]	2.127 [54.0258]
C-180	Gear Hub Bushing	1.500 [38.1000]	1.501 [38.1254]	1.502 [38.1508]

Parts Replacement And Repair

Supercharger Idler Gear

1. It should not be necessary to rebuild this unit unless it has become noisy or loose, thus indicating broken leaf springs or worn bushings.
2. If disassembly is necessary, proceed as follows:

a. Remove capscrews and idler drive hub (5, Fig. 1-3-3), blower gear (18), thrust washer (6) and spring retaining cover (15) from assembly.

b. Carefully pry and remove idler leaf springs (13), 4 spring-retaining pins (12), and separate idler driven gear from spring retainer.

3. Replace all broken or damaged idler leaf springs.
4. Check supercharger idler gear bushings (9) and idler hub bushings (4). See Table 1-3-2.
5. Check idler gear hub; if worn smaller than 2.1215 in. [53.8861 mm], replace hub. New hubs are 2.1225/2.1235 in. [53.9115/53.9369 mm] diameter.
6. Check thrust washer for wear. Replace as needed. See Table 1-3-2.
7. Place spring retainer over idler driven gear cam … idler leaf springs and four pins in place, Fig. 1-3-1.

Caution: Idler leaf springs are made from spring … will cause a serious injury if allowed to fly loose … are forced between gear cam and spring retainer…

8. Assemble thrust washer to idler gear hub, Fig. 1-3-…
9. Mount retainer plate, blower gear and idler gear … secure with capscrews.
10. Peen capscrews in place.

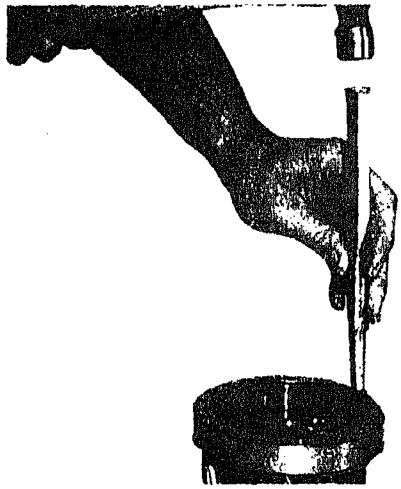


Fig. 1-3-1. Installing idler leaf springs

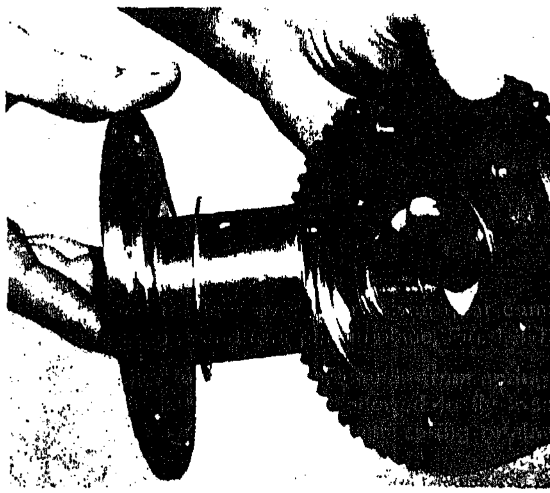
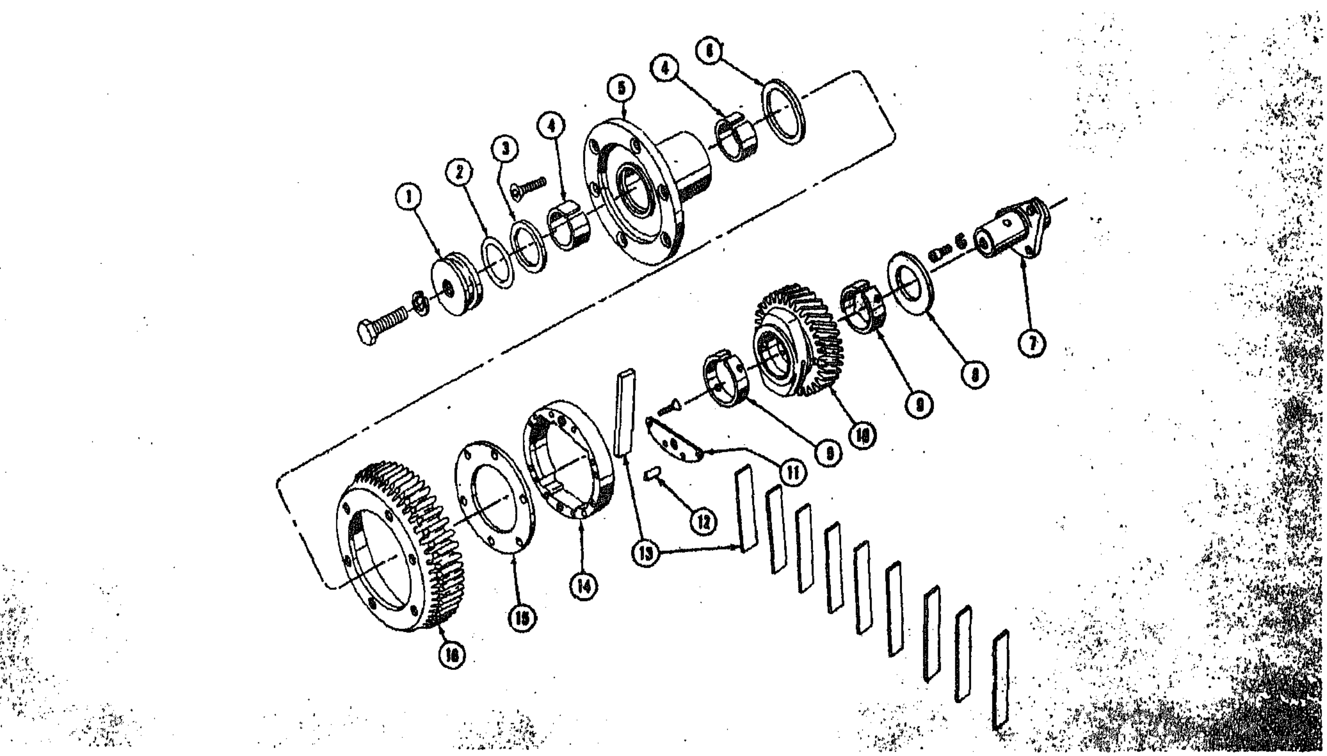


Fig. 1-3-2. Assembling supercharger idler gear



ig. 1-3-3. Supercharger idler gear — exploded view

art lumber	New Dimensions Minimum In. [mm]	Maximum In. [mm]	Worn Limit In. [mm]
8631	0.096 [2.4384]	0.106 [2.6924]	0.091 [2.3114]
8632	0.061 [1.5494]	0.063 [1.6002]	0.059 [1.4986]
8633-1	0.192 [4.8768]	0.194 [4.9276]	0.190 [4.8260]

Table 1-3-2: Idler Thrust Washers

ounterbalancer Drive

he raised counterbalancer has an idler drive gear located n the gear cover; refer to Unit 111 this group.

he counterbalancer located in oil pan has an idler drive ear located on lubricating oil pump; refer to Group 7, nit 705.

Crankshaft—Unit 104

Disassembly

1. If crankshaft gear is chipped, cracked, broken or worn remove lockplate and nut (if used).
2. Attach a circular-type puller, as illustrated in Fig. 1-4-1, behind the crankshaft gear.

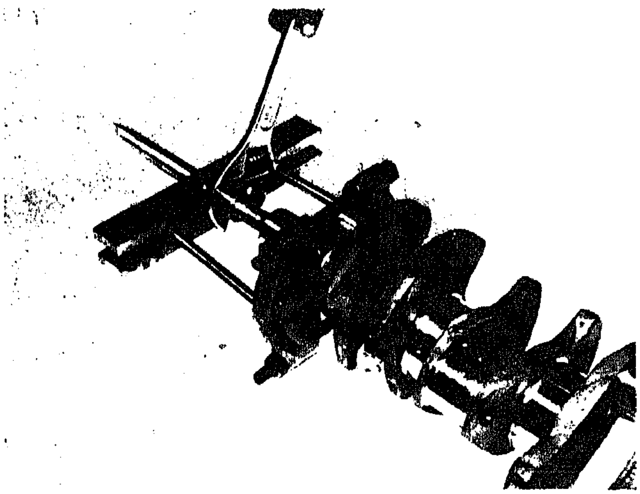


Fig. 1-4-1. Pulling crankshaft gear with ring-type puller N20057

3. Apply 75 to 100 ft. lbs. [10.3725/13.8300 kg m] on puller screw.
4. Heat gear with heating torch — not a cutting torch — to 300°/400° F. [148.9°/204.4° C.]. The gear will expand, making it easier to pull.
5. Remove gear key.
6. If crankshaft gear condition is satisfactory, do not remove.

Cleaning And Inspection

1. Inspect crankshaft visually for scratches, nicks, cracks and obvious wear pattern.
2. Measure crankshaft journals with micrometers. See Fig. 1-4-2 or 1-4-4 and Table 1-4-1.
3. Check crankshaft for out-of-round condition. Crankshafts

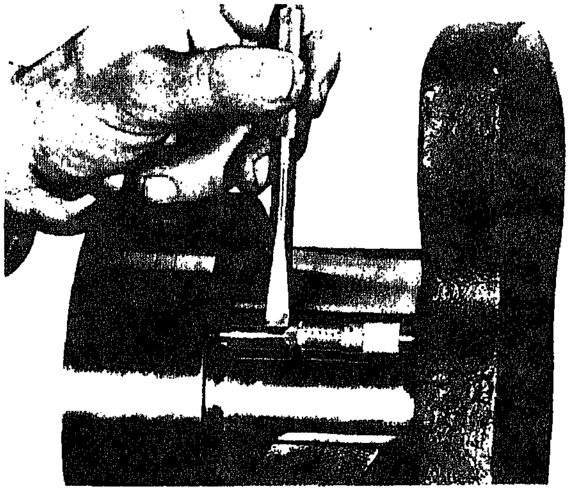


Fig. 1-4-2. Checking thrust flange for wear

are worn out-of-round more than 0.002 in. [0.0508 mm] 1-4-4.

Clean Drillings In Crankshaft

1. Remove all pipe plugs.
2. Clean all drilled oil passages in crankshaft with a ro rag as if cleaning a rifle barrel, Fig. 1-4-6.
3. Install and tighten plugs to 5 ft. lbs. [0.6915 kg m] to
4. Stake pipe plugs by making a 1/64 in. [0.3969 mm] in tion at outside diameter of threads with center punc

Inspect Crankshaft Thrust Flange

1. Carefully examine crankshaft thrust flange at No. 7 bearing (No. 5 on 4 cylinder engines), Fig. 1-4-2. If s is scored or scratched, flange should be regrour oversize thrust rings.
2. Reground crankshafts or those used with oversized rings should be marked so the correct thrust rings installed in their proper position, Fig. 1-4-5.

a. The marking should be stamped on the rear cran web.

b. Both the thrust ring size and ring location must

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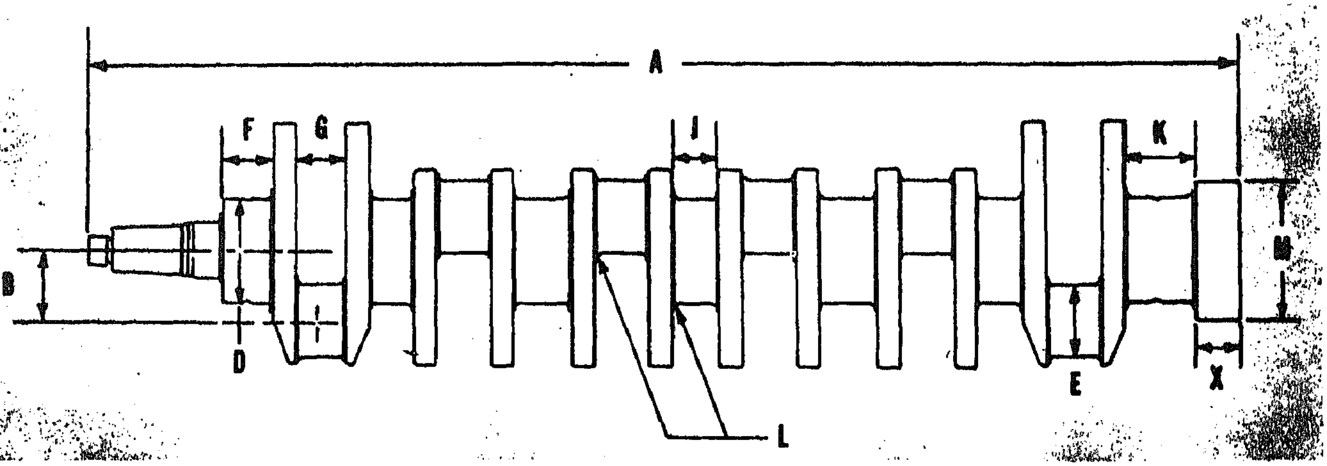


Fig. 1-4-3. Crankshaft dimension points N20158

For example: front — 0.010 in. [0.2540 mm] and rear — 0.020 n. [0.5080 mm].

Measure for flange wear by checking K dimension, Fig. -4-3.

f wear does not exceed 0.003 in. [0.0762 mm] at any one point, flange condition is acceptable.

f wear is 0.003 in. [0.0762 mm] or more, regrind flange to estore flatness. If total wear and regrinding does not exceed 0.005 in. [0.1270 mm], standard thrust rings may be used.

f worn more than 0.007 in. [0.1778 mm], flange should be ground for 0.010 or 0.020 in. [0.2540 or 0.5080 mm] oversize thrust rings or built up by electric arc welding and reground to specifications. Mark as noted in a, b and c above.

g. Regrind must clean up a minimum of 90% of the thrust surface.

h. The regrind or resurfacing must result in maintaining installed crankshaft end clearance below 0.015 in. [0.3810 mm].

Magnetic Inspection

1. Wet complete surface with magnetic particle suspension before applying current.
2. Table 1-4-2 lists magnetizing currents that should be used.
3. Flow magnetic particle suspension over part in advance of placing part through coil. Turn current on coil and move

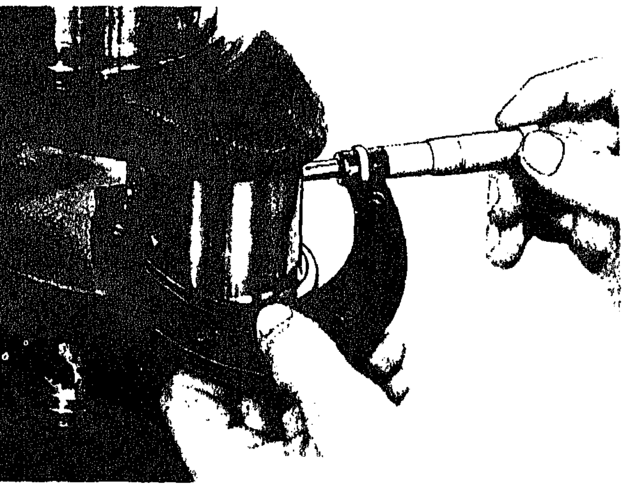


Fig. 1-4-4. Measuring crank pin journal N10123

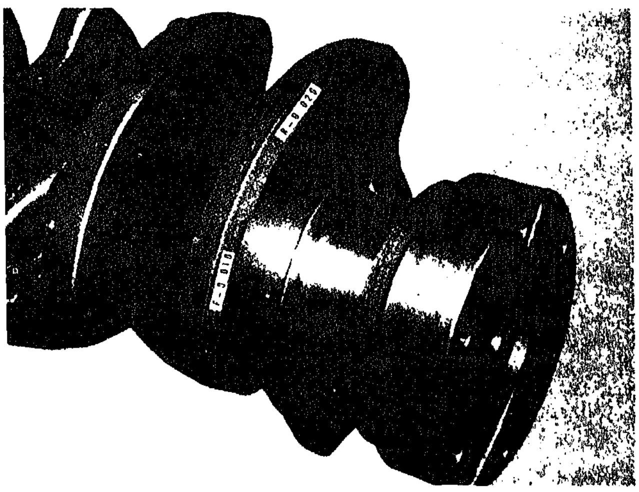


Fig. 1-4-5. Oversize thrust bearing size mark on crankshaft N20159

Table 1-4-1: Crankshaft Dimensions — In. [mm]

Part No.	A	B	D	E	F	G	X	J	K	L	M
10974-1	39.3700 39.3900	2.4950 2.5050	3.8740 3.8750	2.6240 2.6250	1.4320 1.4420	2.0000 2.0030	0.6200 0.6300	1.4320 1.4420	1.4340 1.4360	0.1410 0.1640 R	5.4980 5.5000
10974-1	[999.9980] [1000.5060]	[63.3730] [63.6270]	[98.3996] [98.4250]	[66.6496] [66.6750]	[36.3728] [36.6268]	[50.8000] [50.8762]	[15.7480] [16.0020]	[36.3728] [36.6268]	[36.4236] [36.4744]	[3.5814] [4.1656] R	[139.6492] [139.7000]
106071	39.3700 39.3900	2.4950 2.5050	3.8735 3.8750	2.6235 2.6250	1.4800 1.4900	2.0000 2.0030	1.2600 1.3000	1.4320 1.4420	1.4340 1.4360	0.1410 0.1640 R	5.4980 5.5000
106071	[999.9980] [1000.5060]	[63.3730] [63.6270]	[98.3869] [98.4250]	[66.6369] [66.6750]	[37.5920] [37.8460]	[50.8000] [50.8762]	[32.0040] [33.0200]	[36.3728] [36.6268]	[36.4236] [36.4744]	[3.5814] [4.1656] R	[139.6492] [139.7000]
112330	26.9100 26.9300	2.4950 2.5050	3.8735 3.8750	2.6235 2.6250	1.4800 1.4900	2.0000 2.0030	1.2600 1.3000	1.4320 1.4420	1.4340 1.4360	0.1410 0.1640 R	5.4980 5.5000
112330	[683.5140] [684.0220]	[63.3730] [63.6270]	[98.3869] [98.4250]	[66.6369] [66.6750]	[37.5920] [37.8460]	[50.8000] [50.8762]	[32.0040] [33.0200]	[36.3728] [36.6268]	[36.4236] [36.4744]	[3.5814] [4.1656] R	[139.6492] [139.7000]
112362	29.6800 29.7000	2.4950 2.5050	3.8735 3.8750	2.6235 2.6250	1.4800 1.4900	2.0000 2.0030	1.2600 1.3000	1.4320 1.4420	1.4340 1.4360	0.1410 0.1640 R	5.4980 5.5000
112362	[753.8720] [754.3800]	[63.3730] [63.6270]	[98.3869] [98.4250]	[66.6369] [66.6750]	[37.5920] [37.8460]	[50.8000] [50.8762]	[32.0040] [33.0200]	[36.3728] [36.6268]	[36.4236] [36.4744]	[3.5814] [4.1656] R	[139.6492] [139.7000]
135580	25.7500 25.7700	2.4950 2.5050	3.8735 3.8750	2.6235 2.6250	1.4800 1.4900	2.0000 2.0030	1.2600 1.3000	1.4320 1.4420	1.4340 1.4360	0.1410 0.1640 R	5.4980 5.5000
135580	[654.0500] [654.5580]	[63.3730] [63.6270]	[98.3869] [98.4250]	[66.6369] [66.6750]	[37.5920] [37.8460]	[50.8000] [50.8762]	[32.0040] [33.0200]	[36.3728] [36.6268]	[36.4236] [36.4744]	[3.5814] [4.1656] R	[139.6492] [139.7000]
135581	29.6800 29.7000	2.4950 2.5050	3.8735 3.8750	2.6235 2.6250	1.4800 1.4900	2.0000 2.0030	1.2600 1.3000	1.4320 1.4420	1.4340 1.4360	0.1410 0.1640 R	5.4980 5.5000
135581	[753.8720] [754.3800]	[63.3730] [63.6270]	[98.3869] [98.4250]	[66.6369] [66.6750]	[37.5920] [37.8460]	[50.8000] [50.8762]	[32.0040] [33.0200]	[36.3728] [36.6268]	[36.4236] [36.4744]	[3.5814] [4.1656] R	[139.6492] [139.7000]
146450	39.3700 39.3900	2.4950 2.5050	3.8735 3.8750	2.6235 2.6250	1.4320 1.4420	2.0000 2.0030	1.1510 1.1610	1.4320 1.4420	1.4340 1.4360	0.1410 0.1640 R	5.4980 5.5000
146450	[999.9980] [1000.5060]	[63.3730] [63.6270]	[98.3869] [98.4250]	[66.6369] [66.6750]	[36.3728] [36.6268]	[50.8000] [50.8762]	[29.2354] [29.4894]	[36.3728] [36.6268]	[36.4236] [36.4744]	[3.5814] [4.1656] R	[139.6492] [139.7000]
156290	39.3700 39.3900	2.4950 2.5050	3.8735 3.8750	2.6235 2.6250	1.4800 1.4900	2.0000 2.0030	1.2600 1.3000	1.4340 1.4420	1.4340 1.4360	0.1410 0.1640 R	5.4980 5.5000

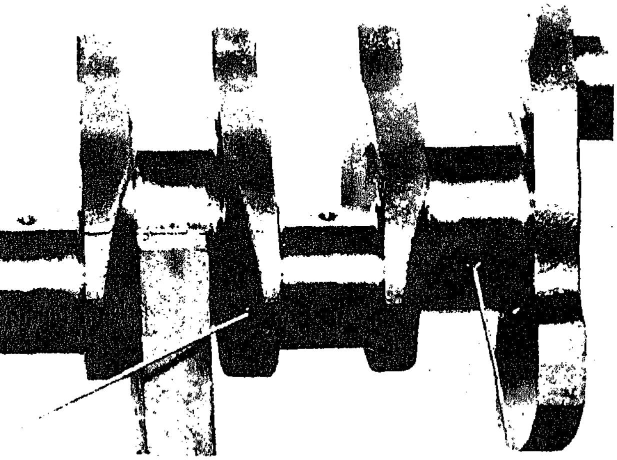


Fig. 1-4-6. Cleaning drilled oil passages N10124

Table 1-4-2: Magna-Flux Magnetization

Direction of Defect	Longitudinal	Circumferential
DC or rectified AC	1200 amps	3600-4000 amp turns
AC equipment	1400 amps	4200-4700 amp turns
Magnetizing Method	Head Shot	Coil Shot

Note: Ampere-turns is amperage flowing through coil multiplied by number of turns in coil; above is for 4-turn coil.

coil full length of part.

f shaft parts are within 2 or 3 in. [50.8000 or 76.2000 mm] of coil I.D., ample magnetism will be obtained if 3 shots of current are passed through coil while it is at each end and center of part length.

Limits of Acceptability.

Unless otherwise stated, limits of acceptability apply only to light slag or oxide stringers usually defined as inherent inclusions. Obvious cracks and circumferential or transverse defects are not acceptable.

Limits listed in following steps must be maintained within region "C" (Critical Region) shown in Fig. 1-4-7. Dimensional value of "C" is vertical distance measured downward from crankpin center-line and extending longitudinally for all crank webs between region "X" on crankpin and region "X" on main journal.

Indications located less than 1 in. [25.4000 mm] from major axis or centerline of adjacent web (measured circumferentially) must not exceed the following limits:

Light indications in or entering fillets are acceptable if not more than 1/8 in. [3.1750 mm] long (open) or 1/4 in. [6.3500

(2) Light open indications on crankpin and main journal walls or bearing surface that extend closer than 1/8 in. [3.1750 mm] to fillets, but do not enter fillets, are acceptable if 3/16 in. [4.7625 mm] long or less. Light subsurface indications are acceptable.

d. Indications located more than 1 in. [25.4000 mm] from major axis or centerline of adjacent web (measure circumferentially) must not exceed following limits:

(1) Light open indication in or entering fillets are acceptable if 3/16 in. [4.7625 mm] long or less. Light subsurface indications are acceptable.

(2) Light open indications on crankpin and main journal walls or bearing surfaces that extend closer than 1/8 in. [3.1750 mm] to fillet, but do not enter fillet, are acceptable if 1/4 in. [6.3500 mm] or less. Light subsurface indications are acceptable.

(3) Nicks on corners of webs are not acceptable. The part will be acceptable if nick can be removed by grinding a 1/8 in. [3.1750 mm] radius on corner.

(4) Imperfections on web periphery may be ground out to a depth of 1/8 in. [3.1750 mm] maximum using a 1 1/2 in. [38.1000 mm] minimum radius grinding wheel, provided balance limits are maintained.

(5) Light open indications that pass within 3/16 in. [4.7625 mm] of a crankpin hole are acceptable if 1/2 in. [12.7000 mm] long or less and do not enter the oil hole chamfer or intersect the 45° ± 10° diagonal. Only those subsurface indications that lie closer than 1/16 in. [1.5875 mm] to surface (measured at the chamfer at a 45° ± 10° diagonal) are not acceptable. All other subsurface indications are acceptable.

e. Light open indications that enter the chamfer of any main bearing oil hole are acceptable if they are 3/8 in. [9.5250 mm] or less. Subsurface indications ending in a main bearing oil hole are acceptable.

f. Fine subsurface, salt and pepper type indications are permitted on upper and lower side of crankpins on trimming line.

g. Open longitudinal indications within region "X" which are less than 1 1/8 in. [38.5750 mm] on the main journals and 7/8 in. [22.2250 mm] long on crankpins, are acceptable after sharp edges have been stoned 0.002/0.004 in. [0.0508/0.1016 mm] below the journal surface.

h. Longitudinal subsurface indications within the area "X" are acceptable.

i. Parallel open indications that meet the requirements of (s) and other requirements on length and frequency are acceptable.

j. Parallel subsurface indications are acceptable.

k. Indications that contain loose or foreign particles or voids left by such particles are not acceptable.

l. Not more than three open indications are to appear on any

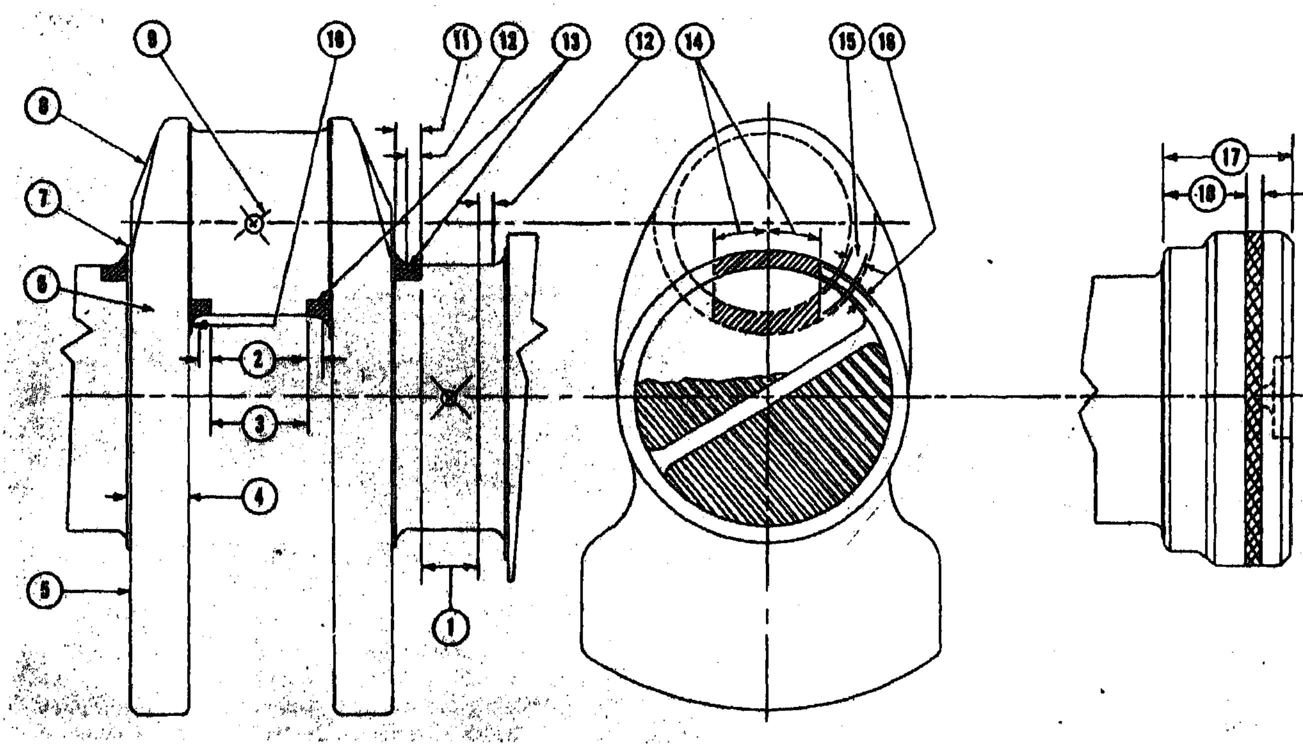


Fig. 1-4-7. Crankshaft magnetic inspection

face indications, four per crankpin, and six per main bearing 1/8 in. [3.1750 mm] long or less, if not forming part of a long intermittent indication or entering an oil hole or fillet, will not be counted as indications in arriving at total number permitted. However, if in addition to showing maximum number of acceptable indications for the whole crankshaft the part also shows many widely scattered short indications, it will be rejected.

m. An inclusion which is intermittently open and subsurface shall be considered and measured as an open indication after the original indication is wiped off. The entire indication must first meet requirements for subsurface limits.

n. Open and subsurface indications on counterweights and crankthrow bevel outside the critical region are acceptable.

o. Seams or indications outside critical region that extend over crank web periphery but are not visible on crankpin wall are acceptable.

p. Open seams on web periphery that show visual depth on crankpin wall may be removed from web periphery with a 1/2 in. [12.7000 mm] radius wheel, provided at least 1/16 in. [1.5875 mm] wall remains above crankpin fillet after repair and balance limits are maintained.

q. Indications due to weld defects are not acceptable in counterweight welds. Indications at corner may be ground out and blended to depth not exceeding 1/4 by 5/8 in. [6.3500 by 15.8750 mm] long.

r. Open longitudinal indications in flywheel and thrust fl fillets longer than 3/8 in. [9.5250 mm] are not acceptable.

s. For limits of indications on oil seal surface refer to 1-4-7. Open Magnaflux indications or machining de that are within specification limits are acceptable in shaded areas around circumference of flange. Open indications which, when wiped clean, do not show s edges, are acceptable in the 3/16 in. [4.7625 mm] sh area.

6. After inspection where coil shot is used, give crank head shot to put magnetic poles at ends of crank, throws. The residual magnetic field should not exceed units on the Magnaflux Field Indicator or equal.

Repair

Check Crankshaft Hardness Before Regrinding

1. All journals should be checked for hardness and check within 40 to 50 Rockwell C.

2. If crankshaft journals check below 40 Rockwell C, the should be hardened to a 0.090 in. [2.2860 mm] min depth and 45 to 50 Rockwell C before regrinding.

3. This check should also be performed after any bearing

ure even though there was no seizure or crankshaft discoloration.

Soft crankshaft journals are more susceptible to high wear rate and breakage than those properly hardened.

Grind Crankshaft

If inspection shows crankshaft is worn to point where it must be reground and magnetic inspection shows it is suitable for regrinding, grind shaft to next standard undersize.

If crankshaft is sent out to a location other than the Factory for regrinding, make sure the regrind shop certifies that all crankshaft journals are hardened to 45/50 Rockwell C.

Caution: This operation must be performed by a shop equipped with adequate equipment and fully trained personnel.

Connecting rod and main bearing shells are available in 0.010, 0.020, 0.030 and 0.040 in. [0.2540, 0.5080, 0.7620 and 1.0160 mm] oversize.

. If crankshaft thrust flange is worn, repair as outlined in "Inspect Crankshaft Thrust Flange" above.

Caution: Grind only the worn thrust face. Install oversize thrust rings on the wearing side only. Failure to do so will move operating position of crankshaft and cause extremely high wear.

. Regrind crankshaft to undersize and hold to specifications shown in Fig. 1-4-3 as noted in the following steps and tables.

. Fillets add greatly to strength of crankshaft. Reducing fillet radii or undercutting subtracts materially from that strength. Conversely, if fillets are larger than those specified, bearing shells may be squeezed and will fail very quickly. Regrind fillets to values shown in Table 1-4-1.

. Grind width of crankpin and main bearings to clean up basic face surfaces.

. If there are deep interruptions such as "gouges" or "nicks" that do not extend into the fillets, smooth the edges with polishing paper.

. A limit of 0.030 in. [0.7620 mm] over the maximum new crankshaft main bearing width specification, Table 1-4-1 shall apply in regrinding.

. The pin wall heights are not to be lowered to less than 0.010 in. [0.2540 mm] from the pin cheeks in regrinding the pin bearing widths on all crankshafts.

. An attempt should be made to keep the pin wall heights as high as possible while still accomplishing the purposes for regrinding.

. All fillet and bearing surfaces should have the same finish as a new crankshaft.

7. Crankshafts requiring "off-stroke" grinding to clean up an unusually bad out-of-round pin bearing can be ground off-stroke a maximum of 0.020 in. [0.5080 mm] over or under the mean stroke dimension of New Crankshaft Specifications, Table 1-4-1.

a. All pin bearings on all crankshafts must be reground to the degree of "off-stroke" required by the worst out-of-round pin bearing.

8. Maximum runout on thrust wall of Thrust Main Bearings shall be 0.002 in. [0.0508 mm] T.I.R.

9. Gear-fit diameter is acceptable when 0.002 in. [0.0508 mm] total indicator runout is not exceeded in relation to adjacent main bearing.

10. Crankshafts with front oil seals may have the flange ground to a diameter not to exceed 0.010 in. [0.2540 mm] under the new crankshaft diameter after grinding and polishing.

11. The entire length of the rear flange may be ground a maximum of 0.003 in. [0.0762 mm] under new crankshaft specifications.

a. If the rear oil seal running area of the rear flange requires more than 0.003 in. [0.0762 mm] grinding, the oil seal area may be step-ground to a maximum of 0.010 in. [0.2540 mm] under the new crankshaft specifications within the distances "B", Fig. 1-4-8. The ledge area "C" must be chamfered 0.040/0.060 in. [1.0160/1.5240 mm].

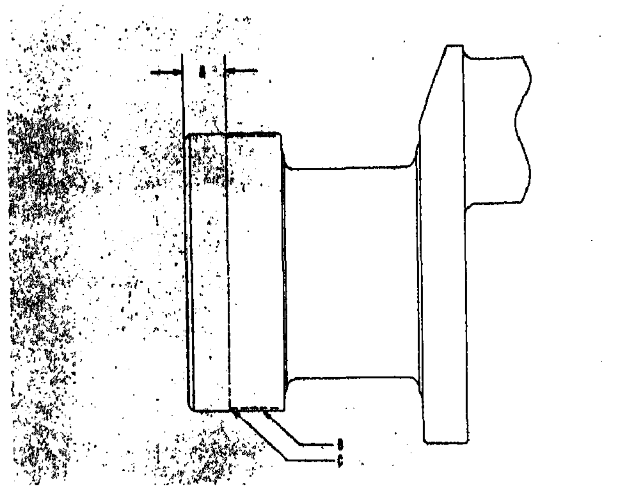


Fig. 1-4-8. Rear seal area regrind specifications N20161

b. The runout on the flange is not to exceed 0.002 in. [0.0508 mm] T.I.R.

12. The flywheel pilot or flywheel adapter pilot diameter (0.40 in. [10.1600 mm] in width area "A" Fig. 1-4-8.) on all crankshafts must not exceed 0.003 in. [0.0762 mm] undersize.

a. The runout on the rear flange is not to exceed 0.002 in.

Chrome Plate Crankshaft

1. Hard chrome plating may be applied only to following crankshaft areas: front taper, gear-fit surface, rear oil seal surface and flywheel flange surface.

Caution: Plating of bearing journals is not acceptable.

2. Surfaces to be plated should be free from pits, tool marks, and all irregularities. Preserve all bevels, chamfers and radii.

3. If necessary, grind surfaces undersize before plating to produce minimum plating thickness of 0.002/0.015 in. [0.0508/0.3810 mm] when plated area is finished to standard diameter.

4. Chemically clean surfaces before plating.

Caution: Protect surfaces not being plated. Make certain drill passages are not contaminated with protective materials used.

5. Plating must be accomplished in a continuous operation. Double plating and spot plating are not acceptable.

6. After surfaces have been plated, heat at 375° F. [190.5°C.] for three hours to remove effects of hydrogen embrittlement.

7. Inspect plated surfaces.

a. Perform magnetic inspection as described above.

b. Check plate for firm bond to base metal, uniformity, freedom from frosty areas, pin holes, nodules, blisters and other defects.

c. Check drilled passages and unplated surfaces to make certain they are free of plating or protective materials.

Assembly

1. Install crankshaft gear, if removed.

Note: Check parts catalog for proper replacement gear.

a. Install key in shaft.

b. Heat gear with heating torch—not cutting torch—to 400°F. [204.4° C.]

c. Lubricate flange with Lubriplate and drive gear onto shaft with piece of tubing.

d. Install lockplate and nut (if used).

Bearings—Unit 105

Main and connecting rod bearings are two-piece units containing an oil hole for lubrication. Thrust bearing "half-rings" are provided at the rear main bearing which then becomes a six-piece unit.

Inspect Bearing Shells

1. Gauge shell with ball point micrometer, dial indicator thickness gauge, or comparator, Fig. 1-5-1.

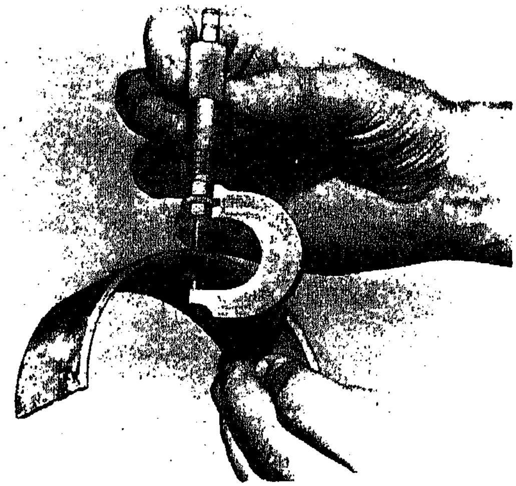


Fig. 1-5-1. Gauging bearing shell N10127

Table 1-5-1: Bearing Shell Thickness — In. [mm]

Bearing Shell	New Dimensions Minimum	Maximum	Worn Limit
Main	0.1231	0.1236	0.1216
Main	[3.1267]	[3.1394]	[3.0886]
Con. Rod	0.0722	0.0727	0.0710
Con. Rod	[1.8338]	[1.8465]	[1.8034]

2. Discard shells that are worn more than 0.002 in. [0.0508 mm] or if chipped, flaked, or scored. See Table 1-5-1 for thickness of standard shells.

3. Total worn maximum oil clearance should not vary more than 0.002 in. [0.0508 mm] between adjacent main bea See Table 1-5-2.

Table 1-5-2: Journal Clearance — In. [mm]

Bearing Shell	New Dimensions Minimum	Maximum	Worn Limit
Main	0.0018	0.0048	0.0068
Main	[0.0457]	[0.1219]	[0.1727]
Con. Rod	0.0020	0.0045	0.0080
Con. Rod	[0.0508]	[0.1143]	[0.2032]

Caution: Under no circumstances should an attem made to scrape bearing shells, nor should they be la or filed to increase oil clearances.

4. A properly fitted bearing will appear dull gray after a sonable period of service, indicating it is running o oil film. Bright spots indicate metal-to-metal contact black spots indicate excessive clearance.

Crankshaft Thrust Rings

1. The best measurement of wear on crankshaft thrust (half-rings) is the crankshaft end clearance check. "Engine Assembly" Section 14.

2. Oversize thrust rings are available as indicated in 1-5-3.

Table 1-5-3: Crankshaft Thrust Rings — In. [mm]

Part Number	New Minimum	New Maximum	Worn Limit
150310	0.151	0.153	*
	[3.8354]	[3.8862]	*
150311	0.161	0.163	*
	[4.0894]	[4.1402]	*
150312	0.171	0.173	*
	[4.3434]	[4.3942]	*
*Use Crankshaft End Clearance Following:			
Crankshaft	0.004	0.015	0.022
End Clearance	[0.1016]	[0.3810]	[0.5588]

3. At any time oversize thrust rings are used, be sure to use the same size (thickness) half-ring on both the upper and lower positions. Stamp crankshaft rear web indicating size used. See Page 1-4-1.

Vibration Dampers—Unit 106

On engines where the vibrating forces are or could become harmful, vibration dampers are supplied.

Viscous Dampers

Viscous dampers operate on a different principle and are not as critical in their operation. Due to design, operation over a greater variation in load and mass is possible.

Cleaning

Viscous dampers should be cleaned of rust, dirt or grease with a suitable solvent cleaner.

Inspection

Dampers are not subject to Field repair; therefore, if inspection shows them to be defective, install a new damper.

Viscous Dampers

1. Spray damper with Spotcheck #3 Developer, Type SKB-4-1, or equivalent.
2. Place damper in oven heated to 200° F. [93° C.]. Allow damper to reach oven temperature.

3. Remove damper from oven and inspect for oil smudges or fluid leakage.
4. If oil smudges appear, discard vibration damper.

   Caution: Make this inspection on viscous-type dampers only.

5. An alternate but less effective method for inspecting viscous dampers is by shaking damper. Movement of loose pieces will be felt or heard if fluid has been lost. Tap front face at outside and inside seal. If seal is broken, a hollow sound is heard at break.
6. The viscous damper cannot be balanced in the Field; if out of balance is suspected install a new damper.

Vibration Damper Mounting Flange

1. Inspect for wear at oil seal contact surface; replace if flange is grooved deeper than 0.005 in. [0.1270 mm].
2. Check damper mounting capscrew hole threads.
3. Maximum eccentricity of the mounting flange, measured on the outside diameter of the pilot, should not exceed 0.004 in. [0.1016 mm] total indicator reading.
4. Wobble of the flange, measured at 2¾ in. [69.8500 mm] radius, should not exceed 0.003 in. [0.0762 mm].
5. The above readings are to be taken after assembly on the engine.

   Caution: Crankshaft must be kept to front or rear thrust limit while wobble is checked.

Connecting Rods—Unit 108

Inspection

1. Magnaflux all connecting rods, caps and bolts; discard if cracks are detected.

   Note: Be sure rod and cap are kept mated at all times.

a. Check rods for cracks with 1800 ampere current AC equipment or 1500 ampere current DC or rectified AC equipment longitudinally between plates.

b. Check rods for cracks with 3000 to 3400 ampere-turns with AC equipment or 2600 to 2800 ampere-turns with DC or rectified AC equipment in a coil. Pay particular attention to shaded critical areas shown in Fig. 1-8-7.

   Note: Ampere-turns is defined as the amperage flowing through the coil, multiplied by the number of turns in the coil. Most coils contain four turns and therefore only 700 amperes need to be applied with DC equipment, or 850 amperes with AC equipment.

c. Apply one and one-half percent wet solution while current is on. Make visual inspection after each application of current.

2. Assemble cap to rod and alternately tighten nuts to operating tension by Template method as described in Table 1-8-1.

Table 1-8-1: Template Tightening Connecting Rod Nuts

Tightening Sequence		Tightening Values Ft. Lb. [kg m]
Step 1	Tighten to	15/20 [2.0745/2.7660]
Step 2	Advance to	30 [4.1490]
Step 3	Loosen all	completely
Step 4	Tighten to	15/20 [2.0745/2.7660]
Step 5	Advance to	30 [4.1490]
Step 6	Advance	60° *check

*If less than 38 ft. lbs. [5.2554 kg m] is required to move nut clockwise, replace bolt.

3. Check crankpin bore with a dial bore gauge or inside micrometers. Correct size is important to provide correct bearing crush. See Table 1-8-2, Fig. 1-8-1 and (6, Fig. 1-8-7).

4. Check piston pin bushing diameter with plug gauge or with inside micrometers. See Table 1-8-2, Fig. 1-8-2 and (4, Fig. 1-8-7).

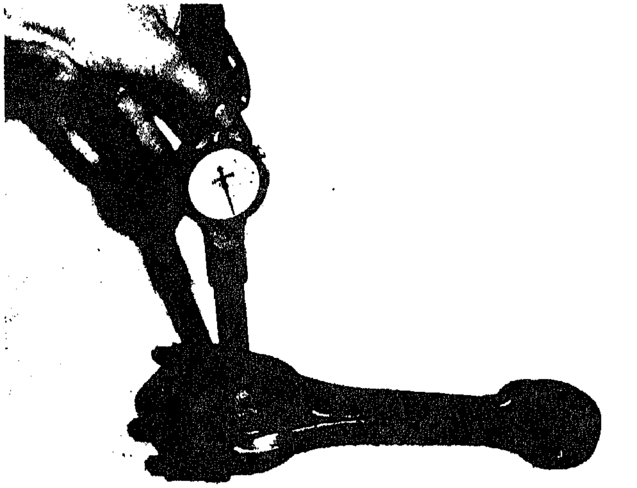


Fig. 1-8-1. Checking connecting rod crank journal bore N20164

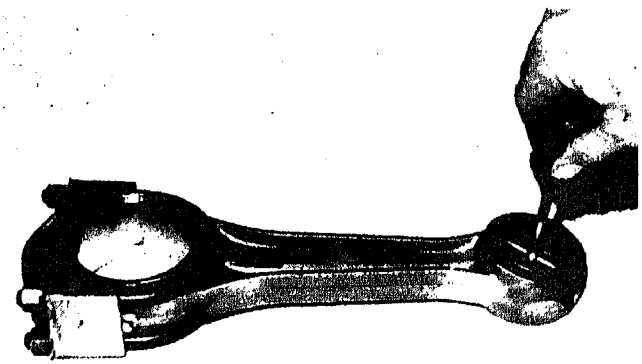


Fig. 1-8-2. Checking connecting rod piston pin bushing N20165

Table 1-8-2: Connecting Rod Dimensions — In. [mm]

Crankpin Bore New Dimensions Min.	Max.	Out-of-Round Limit	Piston Pin Bushing New Dimensions Min.	Max.	Worn Limit
2.7725 [70.4215]	2.7730 [70.4342]	0.0015 [0.0381]	1.5000 [38.1000]	1.5005 [38.1127]	1.5015 [38.1381]

5. Use Checking Fixture and Locating Mandrel to check rod alignment.

Calibrate Checking Fixture For Rod Size

1. Select a new rod that has been checked for correct absolute center to center length. C rods are 9.500 in. [241.3000 mm] between centers. (Production rods may vary from 9.498 in. to 9.500 in. [241.2492 mm to 241.3000 mm] (5, Fig. 1-8-7).
2. Assemble cap to rod as described in Table 1-8-1.
3. Insert piston pin, furnished in mandrel set, in crankpin bore.
4. Insert and tighten ("snug" only) expanding arbor, furnished with Locating Mandrels, in crankpin bore.
5. Set rod in fixture. Fig. 1-8-3.

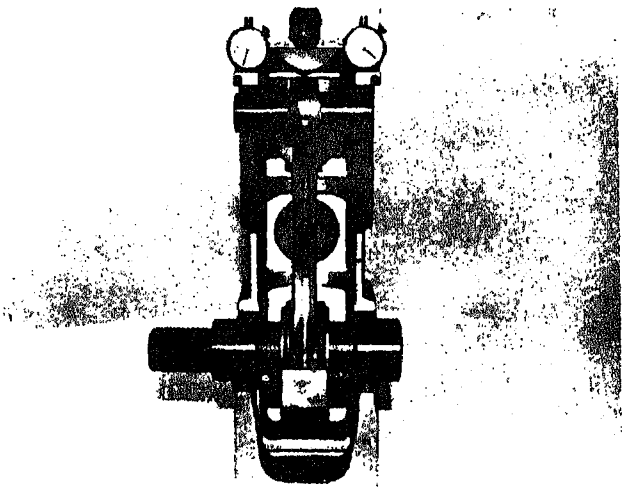


Fig. 1-8-3. Checking rod bore alignment N20166

6. Move dial holder so dials indicate on piston pin.
7. Zero dial indicators.
8. Lift rod, arbor and pin assembly from fixture; turn horizontally 180°; set back in fixture.
9. Readjust dial indicators to divide difference between first and second readings, fixture is now calibrated.

Check Rod Alignment

1. Measurements read directly from dial indicator indicate comparative length and misalignment of bores. Measurements apply with or without bushing installed.
2. Assemble Mandrel in rod to be checked.
3. Set rod in fixture.
4. Take readings for length and misalignment of bores.
5. Turn rod 180°. Total reading must not exceed 0.008 in. [0.2032 mm] when connecting rod **does not contain bushing** or 0.004 in. [0.1016 mm] **with bushing** installed and bored to size. This is combined plus and minus readings of indicator. Length must read ±0.001 in. [±0.0254 mm] on gauges.
6. Measure rod twist with a feeler gauge between piston pin and dial holding plate. Fig. 1-8-4. When measuring connecting rod twist in tool and rod **does not contain piston pin bushing,** twist must not exceed 0.020 in. [0.5080 mm]. Twist must not exceed 0.010 in. [0.2540 mm] **with bushing** in place and bored to size.

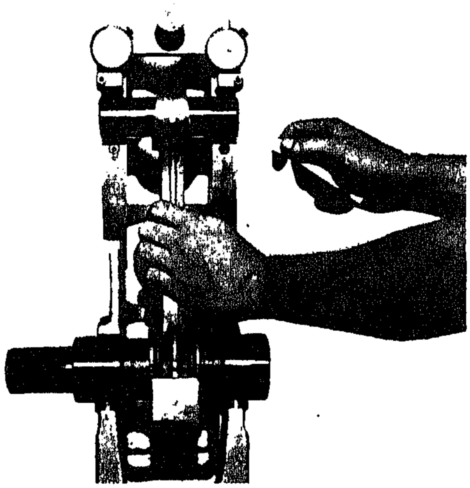


Fig. 1-8-4. Checking rod twist N20167

Check Centerline of Rod

1. Attach indicator so it will contact the side milled surface of piston pin end of rod.
2. Slide crankshaft end of connecting rod sideways to contact plate on same side as indicator gauge. See Step 1.
3. Zero indicator gauge on milled surface.
4. Turn rod 180°; repeat all above checks.

   Note: Difference in reading should not exceed 0.015 in. [0.3810 mm].

Repair Operations

Restore Fillet

1. Minimum 0.070 in. [1.7780 mm] fillet radius at all corners.

(7, Fig. 1-8-7). Maximum $\frac{1}{16}$ in. [1.5875 mm] metal may be milled off to restore radius.

2. Remove nicks and dents which are less than $\frac{1}{16}$ in. [1.5875 mm] deep by grinding or filing with a half-round file. Radius must be $\frac{1}{2}$ in. [12.7000 mm] or more. Blend radii at ends of cut. Scrap rod if dents are deeper than $\frac{1}{16}$ in. [1.5875 mm] (8, Fig. 1-8-7).

Chamfer Piston Pin Bore

1. Chamfering Tool is used to chamfer tapered piston pin bushing bore, if not chamfered.
2. Install proper bushing tool detail by use of flat-head screw.
3. Set the guide screw holder in position; there are three notches, so guide screw will follow on face of bore.
4. Adjust tool fit until point just clears guide screw and tighten in position with two set screws.
5. Install unit into bore.
6. Adjust the guide screw (up or down) until tool bit just engages bore.

   Note: A slight pressure is required against guide screw. To obtain this pressure, tighten set screw in end of holder against guide screw.
7. Insert drive ratchet and turn tool one complete turn to clean up edge of bore.
8. Loosen guide screw and again turn tool one or more complete turns to give a clean cut.

   Note: Repeat until a uniform chamfer of 0.040 to 0.060 in. [1.0160 to 1.5240 mm] depth is reached.
9. Remove tool from bore, turn rod over and chamfer other side of bore.
10. With both sides chamfered, remove tool.
11. Use emery cloth to remove any sharp edges which may have been left on chamfer.
12. Wash rod which is ready for bushing installation.

Replace Piston Pin Bushing

1. Use Mandrel and Block in an arbor press to press out old piston pin bushing. Fig. 1-8-5.
2. Use a straight or tapered sleeve depending upon type of connecting rod.
3. Align oil hole and use Mandrel to press in new bushings to a point flush with milled side surfaces.

   Note: Straight rods use a one-piece bushing. Tapered rods use a two-piece bushing; after Engine Serial No. 284609, these bushings have thicker walls.

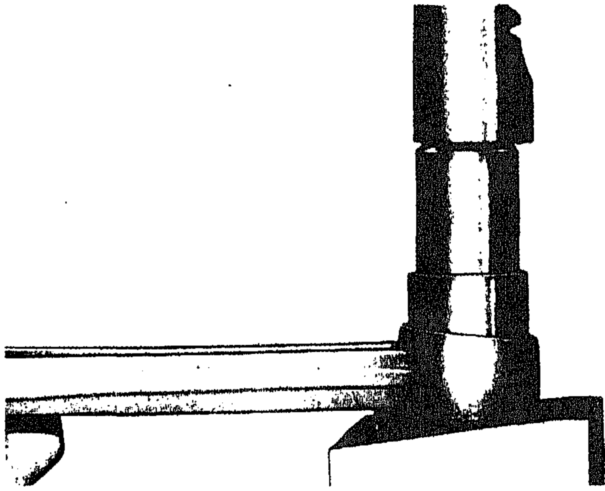


Fig. 1-8-5. Installing piston pin bushing N2(

4. Align tapered bushing half on tapered sleeve and pr flush with milled side surfaces. Turn rod over to install s ond bushing.
5. Fill lubrication holes with soap to keep shavings out.
6. Mount connecting rod in Boring Machine. Fig. 1-8

   Note: Three types of connecting rods are used in the series engines "straight-wide (1, Fig. 1-8-7) 1.5 1.570 in. [39.3700/39.8780 mm] and narrow (2) 1.150/1.160 [29.2100/29.4640 mm] and tapered (3)". Do not mix types rods in any engine.

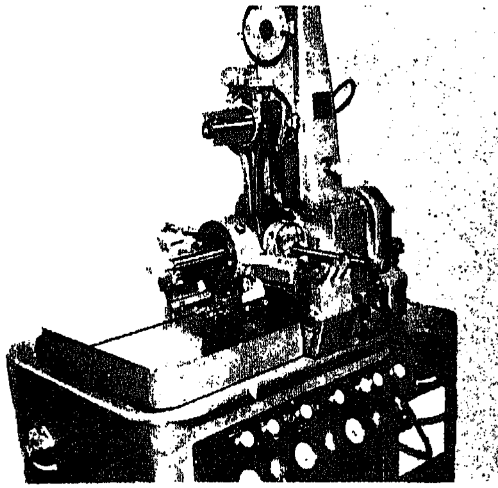


Fig. 1-8-6. Boring piston pin bushing N2(

7. See instruction booklet furnished with the machine for erating procedures.

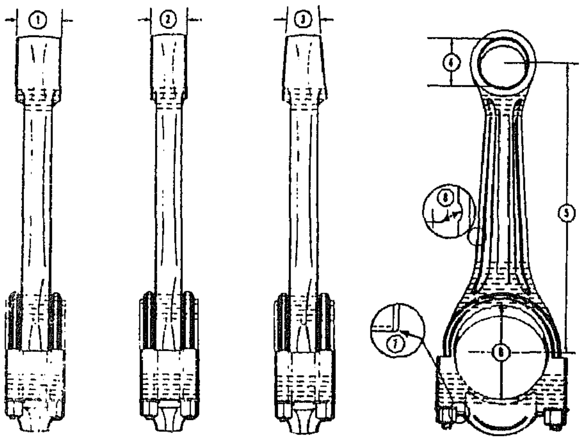


Fig. 1-8-7 Connecting rod specifications N-20169

8. Check rebushed rods as described in previous paragraphs.

9. When reworking wide connecting rods for use with new pistons:

a. Machine piston pin end of connecting rod an equal amount on both sides until it measures 1.150/1.160 in. [29.2100/29.4640 mm] wide

b. Chamfer pin hole 15° by 0.020/0.040 in. [0.5080/1.0160 mm] deep to allow installation of bushing.

c. Install bushings.

d. Bore new bushing to 1.500/1.5005 in. [38.1000/38.1127 mm] (4, Fig. 1-8-7).

e. check rebushed rods.

10. The straight connecting rod is standard for most C Series engines; the tapered rod is used in heavy-duty applications.

Note: The improved tapered rod and piston assembly with thick-wall piston pin bushings can be used in the same engine with the lighter tapered rod and piston assemblies. The additional weight of the improved rod assembly was an increase in rod diameter at the piston pin end and this does not affect operating characteristics of the engine.

Piston and Piston Rings—Unit 109

Piston Rings

Normally, new piston rings are used at the rebuild period. New rings should be checked in the cylinder liner in which they are to be used to make sure the gaps are correct.

1. Insert each ring in mating cylinder liner; position with head of a piston so it is seated squarely.
2. Seat ring in an unworn area of the liner.
3. Measure ring gap with a feeler gauge. Fig. 1-9-1. Gap should fall within limits given in Table 1-9-1.

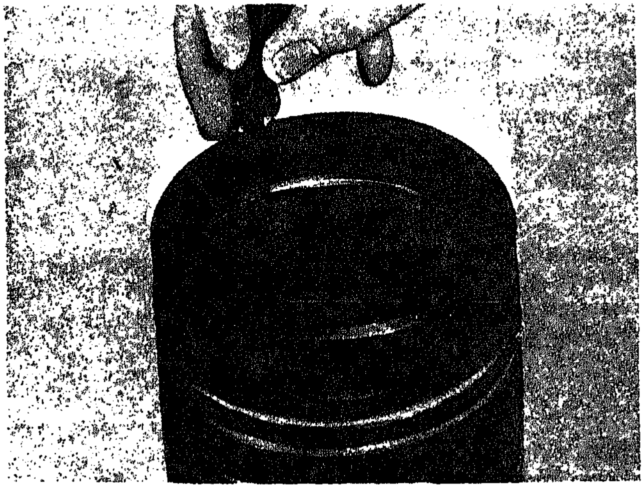


Fig. 1-9-1. Checking piston ring gap N10143

Table 1-9-1: Piston Ring Gap — In New Or Reconditioned Liner

Ring Part No.	Engine Series	Minimum In.	[mm]	Maximum In.	[mm]
112880	C	0.013	[0.3302]	0.023	[0.5842]
144970	C	0.013	[0.3302]	0.023	[0.5842]
145150	C	0.013	[0.3302]	0.023	[0.5842]
118630	C	0.015	[0.3810]	0.055	[1.3970]

4. If necessary, file or stone the ends of the rings to obta the minimum gap.

Caution: Never file or stone chrome-plated rings and nev use chrome-plated rings in chrome-plated cylinder liners

5. Check current parts catalogs to make sure you use prop ring/piston combination.

Note: When used, chrome-plated compression ring is ways installed in top piston ring groove.

6. Pistons and rings are available in standard 0.020, 0.030 a 0.040 in. [0.5080, 0.7620 and 1.0160 mm] oversizes.

Pistons

Cleaning and Inspection

1. Clean pistons in a solvent cleaning bath that will not tack aluminum or blast with a material that will not imb in or remove metal (ground seed, etc.).

Caution: Piston skirts are coated with a plating that m blister if overheated. We recommend that water boili point not be exceeded.

2. After cleaning, check top and second ring grooves with S 560 Ring Groove Wear Check. Fig. 1-9-2.
3. Shoulders of gauge must not touch ring groove lands piston is to be reused. If shoulders touch, discard piston mark piston for regrooving of the top groove.

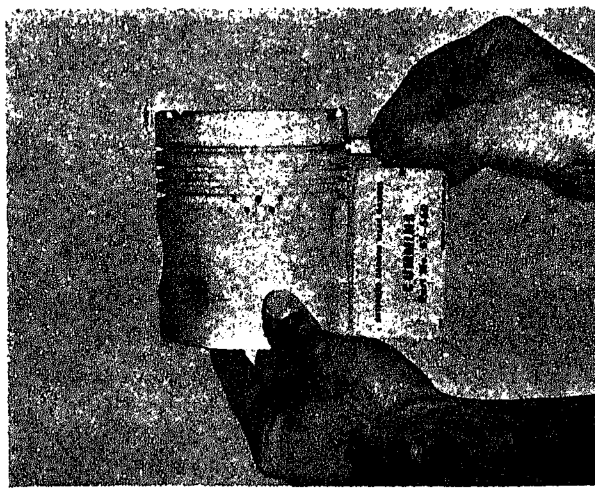


Fig. 1-9-2. Checking ring groove wear N20

Table 1-9-2: Standard Piston Skirt Diameter at 70° F. [21.1° C.] — In. [mm]

Engines Series	Piston Part No.	Compression Ratio	*Gauge Point	New Dimension Minimum	Maximum	Wear Limit
C	130360, 130500	15.8:1	BC	4.4275 [112.4585]	4.4285 [112.4839]	4.4245 [112.3823]
C	**144840, 149200	15.8:1	BC	4.4300 [112.5220]	4.4310 [112.5475]	4.4270 [112.4458]
C	168430	15.8:1	BC	4.4300 [112.5220]	4.4310 [112.5475]	4.4270 [112.4458]

*Refer to Fig. 1-9-3. **Three-ring pistons 144840

. If ST-560 is not available, check wear with a segment of a new ring and a feeler gauge.

Hold ring in groove, flush with land.

Insert 0.006 in. [0.1524 mm] feeler gauge.

. If gauge enters groove without forcing or disengaging ring, wear is excessive and piston should not be used or should be marked for regrooving.

. Measure piston skirt diameter with micrometer at right angle to piston pin bore (2, Fig. 1-9-3 for barrel-ground pistons), measure straight or tapered ground pistons at point 1 and 3. Pistons should not be reused if worn more than indicated in Table 1-9-2 on this diameter.

. Pistons should be checked at temperature of 70/90° F. [21.1/32.2° C.]; see Table 1-9-2.

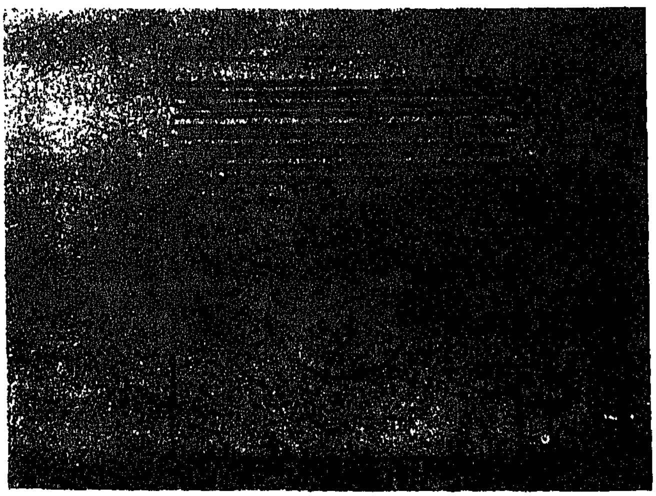


Fig. 1-9-3. Piston check points N20171

Note: After measuring piston and comparing with liner inside diameter, piston-to-liner clearance may be computed if desired.

7. Piston pin bore checked at 70° F. [21.1° C.] should fall within limits shown in Table 1-9-3; add 0.0005 in. [0.0127 mm] per 10° F. [−12.2° C.] up to 90° F. [32.2° C.].
8. Check piston pin outside diameter with micrometers. Pins should not be reused if out-of-round more than 0.001 in. [0.0254 mm] or worn smaller than indicated in Table 1-9-4.

Caution: Reboring of piston pin bores and use of oversize pins is not practical because the misalignment that results from such practice will cause seizure of piston or failure of connecting rod bearings.

Table 1-9-3: Piston Pin Bore — In. [mm]

New Dimensions Minimum	Maximum	Worn Limit
1.4988 [38.0695]	1.4990 [38.0746]	1.5000 [38.1000]

Table 1-9-4: Piston Pin Diameter — In. [mm]

New Dimensions Minimum	Maximum	Worn Limit
1.4988 [38.0695]	1.4990 [38.0746]	1.4978 [38.0441]

Piston Repair

Regroove top ring groove. If piston dimensions are within

limits except for worn top ring groove, groove can be machined to use an over-width ring.

Note: This applies only to aluminum pistons without top ring groove inserts. Observe following precautions when regrooving:

1. Set up piston in lathe or similar device. Make certain piston is held securely without damaging or distorting machined surfaces. Install (15° Grooves) Grooving Tool in lathe.
2. Set tool to only clean up bottom face of groove, removing as small amount of material as possible.
3. The tool is a formed tool so balance of cut will come from top of groove.
4. Hold machined surfaces within 0.0015 in. [0.0381 mm] total indicated runout.

   Caution: Limits must be held accurately for satisfactory ring performance.

5. Stamp letters "OW" (over-width ring) after part number on piston crown.

Piston-To-Connecting Rod Assembly

1. *Pistons are machined to a very close weight tolerance;* therefore, as long as the same part number piston is used throughout the engine weight does not affect engine operation.

   Note: Be sure rod and cap are stamped before disassembly to prevent mixing parts.

2. Connecting rods have the weight (720, etc.) stamped on the rod cap and must be matched with other rods by weight. Total weight between rod assemblies in any one engine should not vary more than 0.03 lb. [13.608 grams]. Weight includes piston pin bushing, bolts, lockplates and bearing shells.
3. Install one piston pin snap ring in piston pin bore.
4. Heat aluminum pistons in boiling water or, not exceeding water boil temperature, in an oven and install pin through piston and connecting rod pin bores before piston cools; at 70° F. the pin fit is 0.0001 to −0.0003 in. [0.025 to −0.0076 mm] which prevents pin assembly unless piston is heated.

   Caution: Never drive piston pins in pistons. Driving may cause distortion of the piston, causing piston seizure in the cylinder liner.

5. Secure pin with second snap ring at opposite end of pin bore.

Camshaft—Unit 110

Cleaning And Inspection

1. Steam clean camshaft assembly.
2. Check camshaft journals with micrometers. Fig. 1-10-1.

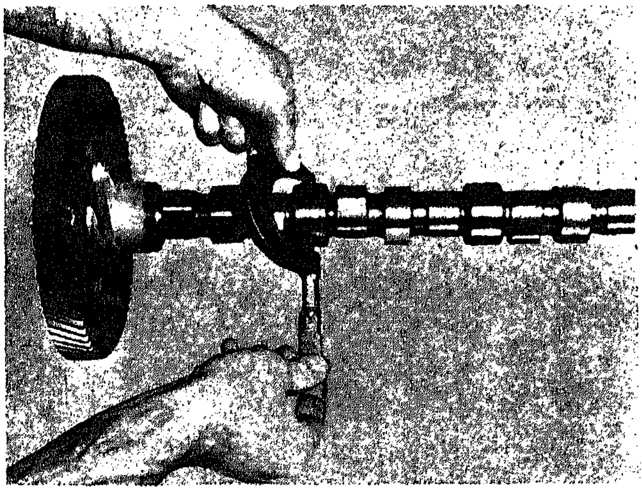


Fig. 1-10-1. Measuring camshaft journals N20172

3. Replace camshaft if journals are worn beyond limits given in Table 1-10-1.
4. Replace camshafts that have scuffed, scored, or cracked injector or valve lobes. Check by magnetic inspection for possible cracks.

Magnetic Inspection

These instructions apply to the magnetic particle inspection using "Magnaflux". The camshafts should be tested by the active or continuous method. That is, the whole surface must be wetted with the magnetic particle suspension before the magnetizing current is applied. Shafts must be magnetized by a single "shot" of current.

1500 amperes DC longitudinal magnetizing currents must be used for locating open seams and the presence of non-metallic inclusions; for detecting grinding checks a circular (coil) magnetizing current of 2000 amperes DC must be used. Limits of acceptability for injector cam:

Table1-10-1: Camshaft Journal Diameter — In. [mm]

Engine Series	Position	New Dimensions Minimum	Maximum	Worn Limit
C	No. 1 only	1.747 [44.3738]	1.748 [44.3992]	1.746 [44.3484
C	All other	1.872 [47.5488]	1.873 [47.5742]	1.871 [47.5234

1. Subsurface longitudinal indications:

a. None acceptable on nose.

b. Short longitudinal indications up to 5/8 in. [15.8750 long are acceptable in the critical region on the cam face, 1/2 in. [12.700 mm] before nose, and 3/8 in. [9.5250 after nose.

c. Not more than two indications are allowable in the crit region of any one cam.

d. Light longitudinal indications not exceeding two in n ber are allowable outside of the critical regions.

e. Parallel indications must be separated by at least 1/1 [1.5875 mm] of metal.

2. Open longitudinal indications:

Open indications are not allowable except on the base cle. A maximum of two longitudinal open indications 1/ [6.350 mm] long or less will be allowed on the base ci provided they are not closer together than 1/4 in. [6 mm] and are visible only as a tightly closed line when surface is wiped clean. Open indications shall not be cl than 3/16 in. [4.7625 mm] to the edge of the cam.

3. Circumferential indications (lying at an angle greater 15° with the longitudinal centerline) are not allowable

Limits of Acceptability for Valve Cams

1. Subsurface longitudinal indications:

a. 1/8 in. [3.175 mm] indications are allowable on the

b. Light longitudinal indications up to 1/2 of the car allowable on the ramp.

c. Not more than two indications are allowal or nose of any one cam.

Light longitudinal indications not exceeding two in number are allowable on the base circle of any one cam.

Parallel indications must be separated by at least ¼ in. [6.350 mm] on the ramp and nose by $\frac{1}{16}$ in. [1.5875 mm] on the base circle.

Open longitudinal indications:

Open indications are not allowable except on the base circle. A maximum of two longitudinal open indications ¼ in. [6.350 mm] long or less will be allowed on the base circle provided they are not closer together than ¼ in. [6.350 mm] and are visible only as a tightly closed line when the surface is wiped clean. Open indications should not extend closer than $\frac{3}{16}$ in. [1.5875 mm] to the edge of the cam.

Circumferential indications (lying at an angle greater than 15° with the longitudinal centerline) are not allowable.

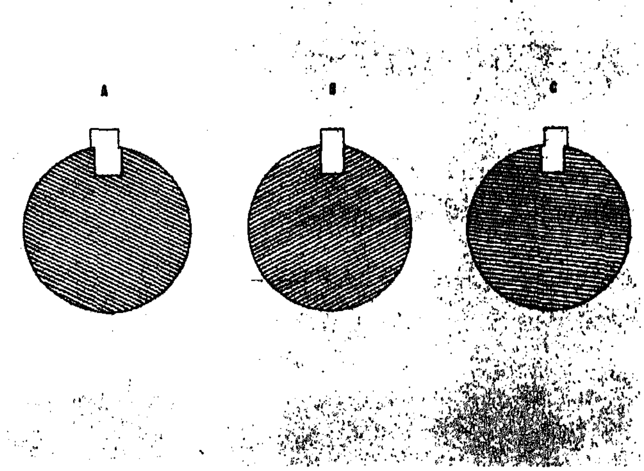


Fig. 1-10-2. Camshaft gear key from gear case end N20173

Limits of Acceptability for Bearing Surfaces

Subsurface indications are acceptable.

Open indications:

Four open longitudinal indications are permitted in each section of bearing provided not more than half of them extend the full width of the bearing. Edges of such indications are to be stoned, not to exceed 0.005 in. [0.127 mm] deep.

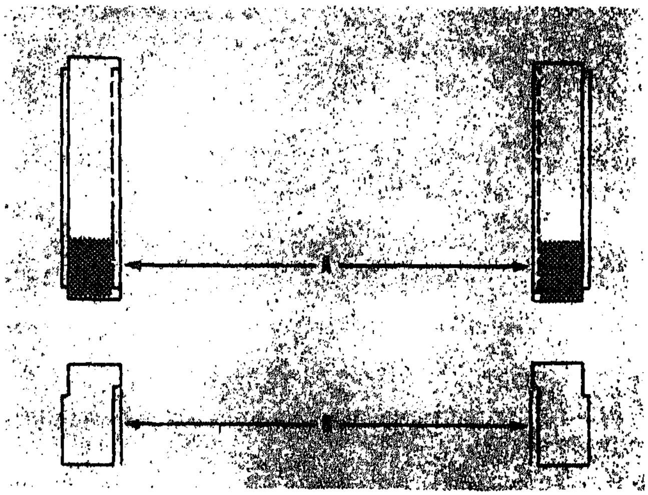


Fig. 1-10-3. Camshaft key markings N20174

Gear

Remove gear if chipped, cracked or visibly worn.

Gears with three capscrew mounted thrust bearing must be pulled from the camshaft.

Slide two steel bars, 4 in. [101.6 mm] by 1 in. [25.4 mm] behind gear and thrust bearing.

Insert gear puller jaws through access holes in gear.

Tighten puller bolt until gear is free of camshaft.

Camshafts with two capscrew mounted thrust bearing:

Place camshaft and gear in press. Support gear as near hub as possible by using short bars lying parallel with thrust bearing.

Press camshaft from gear.

Note: Care must be taken to prevent gear breakage due to improper use of press and support bars.

Note type of key used. See Fig. 1-10-2, "A" — retard from straight, "B" — straight, "C" — advance from straight, as viewed from gear case of engine. Fig. 1-10-3 shows position of color code in "A" and offset in "B". Replace key.

Table 1-10-2: Camshaft Keys

Part Number	Color Code	Amount of Offset Cam Degree	Dimension — In. [mm]
S-302	None	0	0
120602	Red	1½°	0.018/0.020 [0.4572/0.5080]
134088	Blue	2½°	0.031/0.033 [0.9874/0.8382]
146135	None	1½°	0.018/0.020 [0.4572/0.5080]

5. Coat gear hub area of camshaft with Lubriplate.

6. Install camshaft thrust bushing on camshaft with grooves in bushing toward gear.

Table 1-10-3: Camshaft Lobe Lift Measurements

Cam No.	Engine Models	Effective Engine	Effective Date	Superseded Camshaft Number	Injection Spec. BTC	Injection Spec. ATC	Valve Overlap	Exhaust Opens BBC	Intake Opens BTC	Exhaust Closes ATC	Intake Closes ABC	Valve Lobe Lift X	Inj. Lobe Lift
121580	C-180	216349	7/58	116693	64°	19°	88°	62°	44°	44°	40°	0.251 in. [6.3754 mm]	0.112 in. [2.8448 mm]

Note: The above lobe lift measurements are based on nominal values for checking camshafts not installed in engine and do not represent wear values.

7. Heat gear evenly to 400° F. [204.40° C.] with heatin (not a cutting torch).

8. Press on new camshaft gear, aligning gear keyw camshaft key.

9. Check between thrust bearing and camshaft gear f to 0.011 in. [0.178 to 0.2794 mm] clearance for ne bearing.

Gear Cover—Unit 111

Inspection

1. If not removed, remove all oil seals and bearings.
2. Check bearings and discard if rough running or worn. Some bearings are two-piece with inner race remaining on drive unit shaft.
3. Check trunnion for wear; replaceable bushings are available to "rebuild" outside diameter.

Parts Replacement And Repair

1. Press new bushing or bearings into cover as required.
2. Do not install oil seals until gear cover is to be assembled to engine; this prevents collection of dirt which could get into bearings, etc.

Gear Cover Trunnion

1. If gear trunnion on cover is to be "bushed", install as follows:
2. Machine gear case trunnion to 4.747/4.750 in. [120.5738/120.65 mm] outer diameter. Fig. 1-11-1.
3. Press bushing (Part No. 68226-1) over machined trunnion with chamfered side of bushing toward gear case.

Accessory Drive Bore (Bearing Equipped)

If bore is worn or bearing (not applicable to bushing equipped gear covers) has turned and destroyed proper bearing fit, accessory drive bearing bore may be rebushed as follows:

1. Locate center of bore, using seal bore surfaces.
2. Bore bearing bore to 2.7545/2.7550 in. [69.9643/69.9770 mm] diameter and to same depth as original bearing bore.
3. Press sleeve (Part No. 136578) into bored hole. End of sleeve is chamfered for easy assembly.
4. Dress off sleeve flush with gear cover.

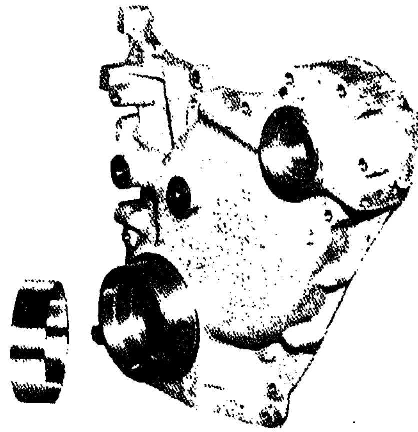


Fig. 1-11-1. Gear case cover and trunnion bushing

5. Drill oil drain hole through bottom of sleeve v drill.
6. Bore inside diameter of sleeve to 2.4408/2.4414 i 62.0115 mm].
7. Chamfer sleeve 0.080/0.100 in. [2.0320/2.5400 mm facilitate bearing installation. Remove all burrs.

Assembly

Accessory Drive Bore (Bearings)

1. Remove dirt and burrs from bearing bore.

   Note: Current gear covers have a bushing inste ing at this location.
2. Coat bearing bore of gear case cover with t Lubriplate.
3. Press bearing in from front to 0.572/0.577 ir 14.6568 mm] depth.
4. Check depth from front of cover.

Accessory Drive Bore (Bushing)

1. Inspect bushing for wear, install new

an 1.322 in. [33.5788 mm]. Be sure oil hole is indexed.

ndersize inside diameter bushings are available for use here accessory drive or air compressor crankshaft is worn r ground undersize. See Table 1-11-1. Shaft to bushing learance should be maintained between 0.002/0.0075 in.).051/0.1907 mm].

able 1-11-1: Accessory Drive Bushing I.D. — In. [mm]

art lo.	Size	New Minimum	New Maximum	Worn Limit
39810	Std.	1.314 [33.3756]	1.319 [33.5026]	1.3205 [33.5407]
39811	0.010 [0.2540]	1.304 [33.1216]	1.309 [33.2486]	1.3105 [33.2867]
39812	0.020 [0.5080]	1.294 [32.8676]	1.299 [32.9946]	1.3005 [33.0327]

Rear Cover—Unit 112

The rear cover is a unit subject to replacement of seals only. Damaged housings require replacement by a new assembly or installation of a "Heli-Coil" for stripped threads; these are the only items of repair.

Alignment during engine assembly is the biggest factor to proper performance of the rear cover unit. The outer machined surface indicated by arrows in Fig. 1-12-1 is provided so the rear cover may be properly centered around the crankshaft. Attach indicator to crankshaft with point resting on machined surface and maintain within a maximum of 0.005 in. [0.0127 mm] runout.

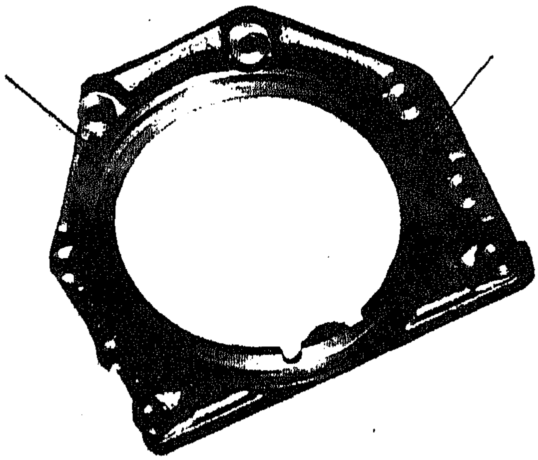


Fig. 1-12-1. Rear cover location surface N20176

Cylinder Head Group

The cylinder head group covers the complete disassemb inspection, repair and assembly of the cylinder he valves, guides, crossheads, valve seats, injector slee and valve springs.

Cylinder Head—Unit 201

Measurements

All dimensions in this group are listed in both U.S. and Metric units. The Metric units are enclosed in brackets [ ].

Disassembly

1. Steam clean complete head assembly.
2. Place cylinder head in Head Holding Fixture See Fig. 2-1-3.
3. Remove valves and springs. Use Valve Spring Compressor to compress valve springs.

Caution: If removing valve springs on an installed engine, be sure piston is up to support valves in cylinder. Replace springs before barring the engine or valve will drop into cylinder necessitating cylinder head removal to retrieve valve.

4. Screw stud from tool in rocker lever bearing capscrew hole.
5. Compress one valve spring at a time. Fig. 2-1-1. Tap valve head lightly to loosen; then remove half collets.
6. Withdraw valves, valve springs and retainers (and valve spring guides, if used).
7. Remove vent tubes or ventilators from naturally aspirated engine; supercharged and turbocharged engines have pipe plugs in the breather holes. Fig. 2-6-3.

Inspection And Cleaning

Water Test Cylinder Head

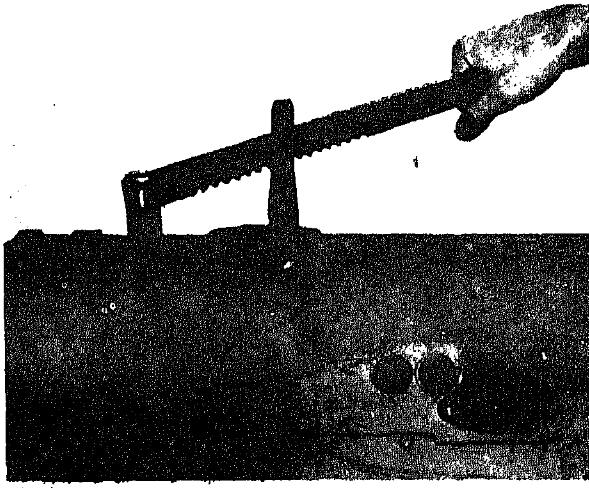


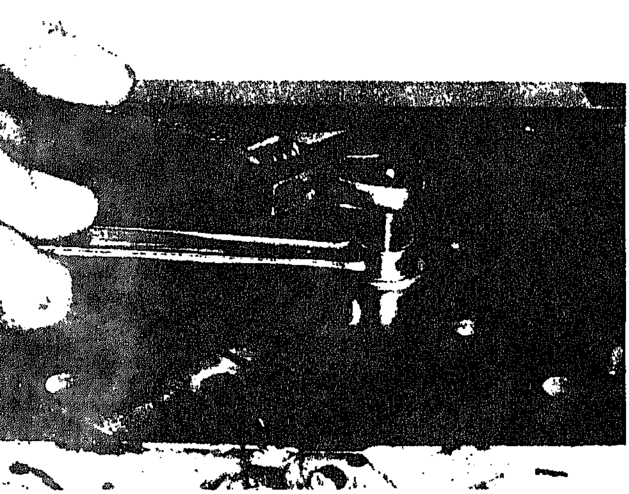
Fig. 2-1-1. Compressing valve springs N

a scrap injector and cup assembly in each injector sle

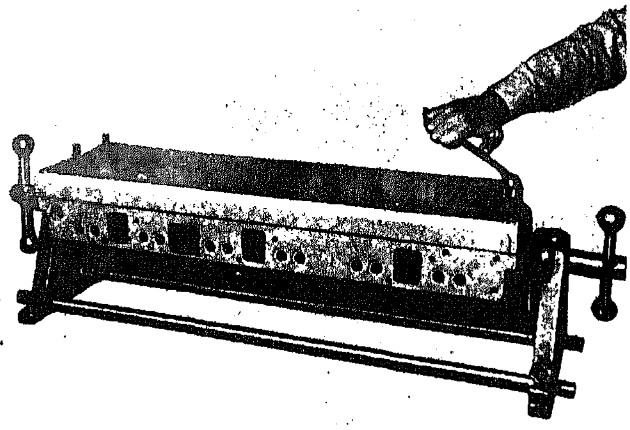
2. Tighten sleeve holding tool to 10/12 ft. lbs. [1.3820/1. kg m] to seal lower end of injector sleeve, or install in tors and secure with capscrews torqued to same va Fig. 2-1-2.
3. Test cylinder heads for leaks at 35/85 psi [2.4605/5. kg/sq cm] and, if possible, at 175°/200° F. [79°/93° C.] w temperature. Check carefully around valve seats and jector sleeve seats for any cracks, even though such cr might not show water leakage. This type crack is cau when injector capscrews are tightened beyond fac torque recommendation. Discard head if cracked.
4. Open water outlet valve of test fixture; check for free w circulation through cylinder head. If restriction is evid remove plugs and injector sleeves; clean water jacket salt, lime or sludge as follows:

a. Remove all pipe plugs and the fuse plug from cyli head.

b. After steam cleaning and disassembly, submerge hea



ig. 2-1-2. *Install injector sleeve holding tool* N20204



ig. 2-1-3. Cylinder head in head holding fixture N20201

ank of cleaning solution heated to near boiling tempera-
ure.

Circulate solvent to increase effectiveness on salt or lime
leposits, grease, etc.

o remove heavy deposits of lime, use circulated acid-type
leaner.

**Caution: The use of acid is extremely dangerous to work-
nen and injurious to machinery. Acid should never be used
n machine shop or near any machine subject to rusting.
lways provide a tank of strong soda water as a neutraliz-
ng agent.**

Check oil transfer dowel at center of head to make sure oil
assage is open so oil will flow to the rocker lever
earings.

Magnetic Crack Detection

Inspect the valve and injector port areas using a portable magnetic crack detector. Fig. 2-1-4. Instructions for the use of this device are on the inside cover of the carrying case.

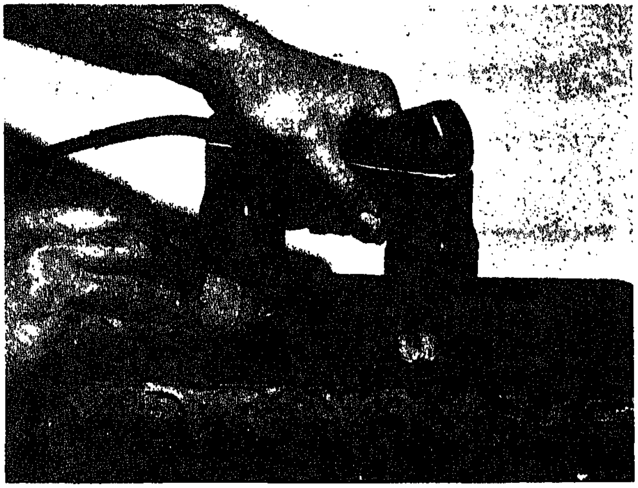


Fig. 2-1-4. Inspecting valve and injector port areas N20225

Crosshead Guides

1. Solid type:

a. Check guide Outside Diameter with micrometers. See Table 2-1-1 for worn replacement limits.

b. Check guide for straightness. It should be at right angles with *milled surface of head. Replace if not straight or if* worn beyond replacement limit.

2. Tubular type:

a. Set inside micrometers 0.0002 in. [0.0051 mm] larger than worn replacement limits shown in Table 2-1-1 and use as "no-go" gauge to check wear. Fig. 2-1-5.

b. Check bore at several points.

Table 2-1-1: Crosshead Guide Dimensions — In. [mm]

Type	New Minimum	New Maximum	Worn Limit
Tubular (Inside)	0.3755 [9.5377]	0.3760 [9.5504]	0.3780 [9.6012]
Solid (Outside)	0.3750 [9.5250]	0.3755 [9.5377]	0.3740 [9.4996]

Fig. 2-1-5. Checking crosshead guide N20207

c. Mark guides for replacement that are not within worn replacement limits.

3. Check crosshead guide protrusion above cylinder head. See Page 2-4-1.

Cylinder Head Fuse Plug

Some cylinder heads are equipped with fuse plugs containing a metal-alloy center that melts if the engine is overheated. Fig. 2-1-6.

1. Examine fuse plug for signs of overheating.
2. Install new plug if metal alloy has melted. Fig. 2-1-6.

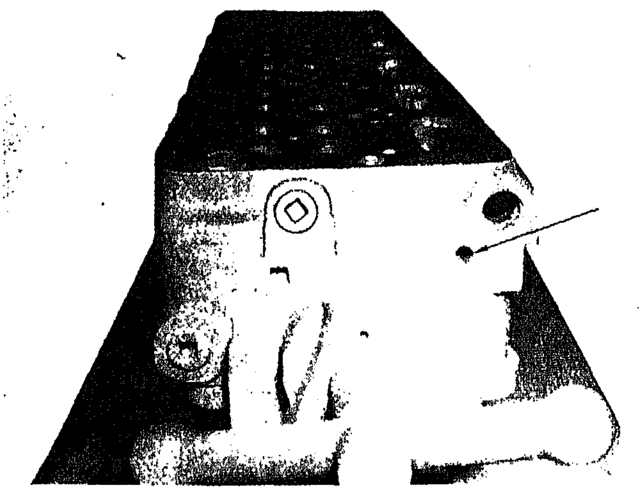


Fig. 2-1-6. Fuse plug location N20203

3. As other engine disassembly proceeds, check carefull damage from overheating.

Valve Seats

1. Check for loose valve seat inserts by lightly tapping near inserts. A slight looseness, which can be found by tapping, when head is cold and covered with film is not objectionable.
2. If valve seat insert is loose enough to bounce or cann reground, mark for replacement. See: VALVE SEAT SERTS, Page 2-3-1.
3. If seat area width (2, Fig. 2-1-7) exceeds 0.125 in. [3 mm] at any point (see A to B), and cannot be narrowe sufficiently it is unlikely that seat can be successfull ground. See GRIND VALVE SEATS, Group 2.

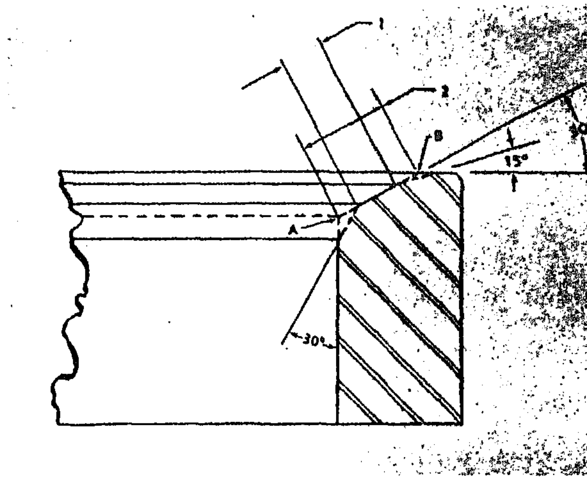


Fig. 2-1-7. Valve seat insert cross-section

Injector Sleeves

1. Note results of water test. Leaks indicate need for rep ment.
2. Visually check sleeves which pass the water tes scratches on cup seat area and mark for replaceme seat area is scratched.
3. Lightly coat a new injector cup on injector body with sian Blue. Install in injector sleeve and torque injecto injector sleeve evenly to operating tension. Remove check seat pattern. If indicated seat width does not at least 0.060 in. [1.5240 mm] wide continuous contact, sleeve for replacement.
4. Check seat depth:

Install injector assembly. Torque injector capscrews to 10/12 ft. lbs. [1.3820/1.6584 kg m]. If so equipped, torque ny-lock capscrews to 12/14 ft. lbs. [1.6584/1.9348 kg m].

Measure tip protrusion with dial indicator as shown in Fig. 2-1-8. Injector cup tips should protrude 0.040/0.055 in. [1.0160/1.3970 mm] beyond cylinder head milled surface. Maximum allowable protrusion is 0.065 in. [1.6510 mm].

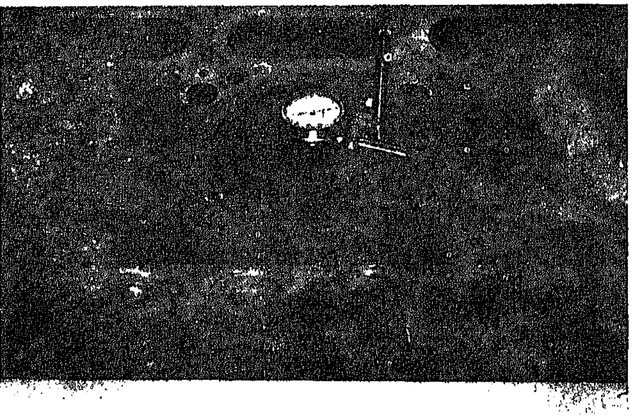


Fig. 2-1-8. Measure injector tip protrusion N20206

Remove unusable sleeves by cutting them from cylinder head with a ³/₈ in. [9.5250 mm] gouge chisel and driving out from lower end.

Repair

Sleeve Eroded Water Holes

The cylinder head surfaces around the water holes must be free of any erosion, pits, scratches or blemishes which are more than 0.003 in. [0.0762 mm] deep in the area $\frac{1}{16}$ to $\frac{5}{32}$ in. [1.5875 to 3.9687 mm] from edge of water holes. Repair as follows:

Insert hold-down adapter into injector sleeve.

Position tool on head with reamer guide hole over water hole to be repaired.

Insert tool hold-down knob into holder assembly and tighten down finger tight. Fig. 2-1-9.

Insert locating pin into eroded hole and tighten hold-down knob.

To set depth of reamer assembly, insert assembly in guide. Place bushing between holder assembly and reamer ad-

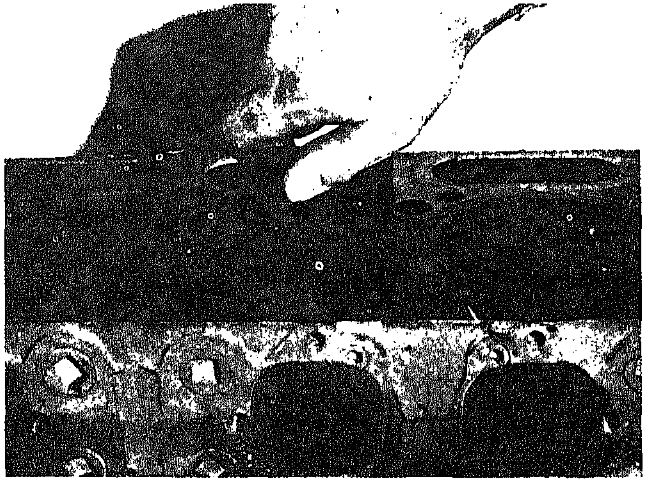


Fig. 2-1-9. Inserting hold-down knob into holder assembly N20226

justable stop collar. Insert 0.005 in. [0.1270 mm] feeler gauge between bushing and adjustable collar; tighten capscrew. Fig. 2-1-10.

Caution: Take care not to use too large a reamer.

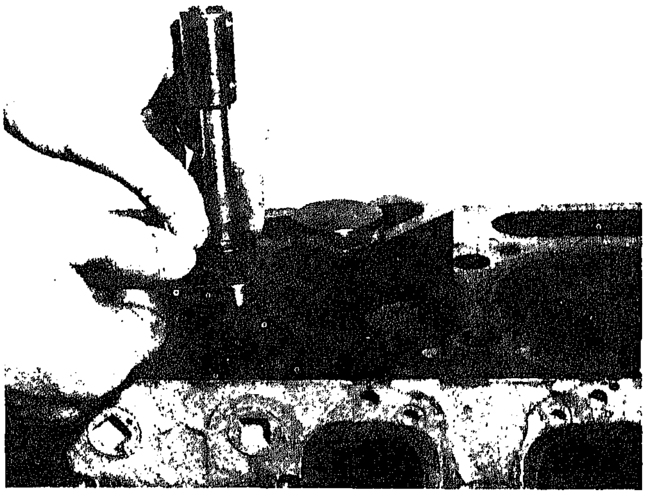


Fig. 2-1-10. Setting reamer depth N20227

6. Attach drive adapter to a drill chuck and place grooved end of drive adapter into reamer assembly.

7. Ream out eroded water hole until collar bottoms against tool.

8. Remove drill, reamer assembly, holder assembly and hold-down adapter.

9. Drive bushing into reamed hole with driver. Fig. 2-1-11. Bushing should protrude about 0.003 to 0.005 in. [0.0762/0.1270 mm].

10. If head is to be resurfaced, see "Resurface Cylinder Head". If head is not to be resurfaced, file bushing flush with head, using a wide flat mill file.

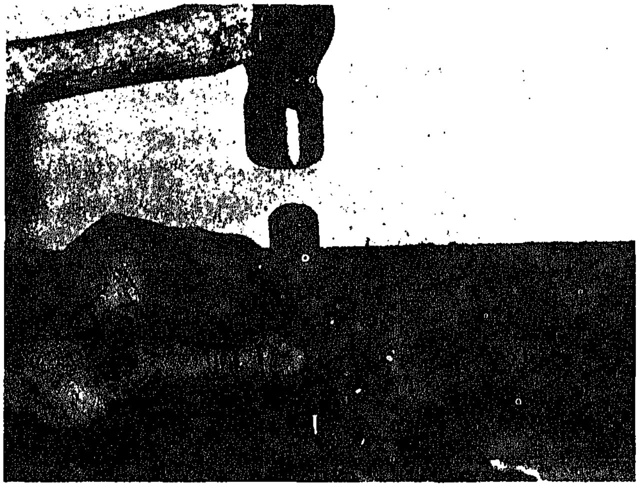


Fig. 2-1-11. Driving bushing into hole N20228

Resurface Cylinder Head

1. Resurface head if it has been scratched, etched or worn unevenly at point of contact with gasket sealing areas. C or J heads warped as much as 0.019 in. [0.4826 mm] will flatten out when tightened in position; therefore, it is not necessary to resurface only because of warping. Also, check erosion around water holes which could cause failure of head gasket to seal. If eroded, install bushings before resurfacing head.

2. Remove 0.005/0.006 in. [0.1270/0.1524 mm] material at one time and no more than 0.030 in. [0.7620 mm] total. Table 2-1-2.

Table 2-1-2: Head Height — In. [mm]

New Minimum	New Maximum	Worn Limit
5.000 [127.000]	5.010 [127.2540]	4.970 [126.2380]

3. Rework valve seat insert counterbore by removing amount

eration. See Page 2-3-1.

4. Sand surface of cylinder head with an orbital sander. **not use a disc sander.** Do not allow the sander to tilt rock, since this may result in rounding of the machi edges. Fig. 2-1-12.

5. After resurfacing:

a. Check head height; see Table 2-1-2 for head dimensio Use micrometer or vernier calipers for accurate measu ment. Fig. 2-1-13.

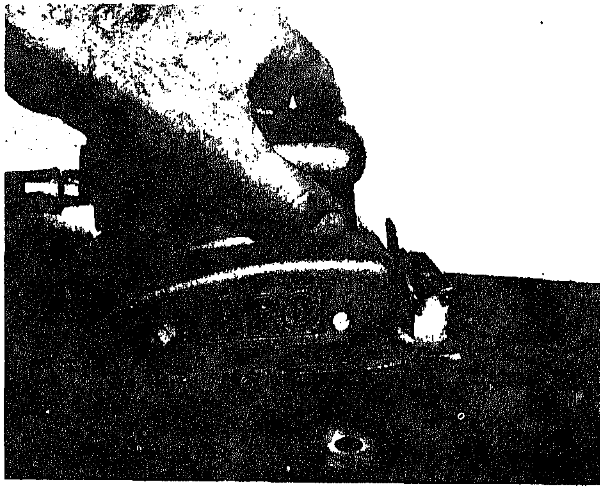


Fig. 2-1-12. Sand cylinder head N2

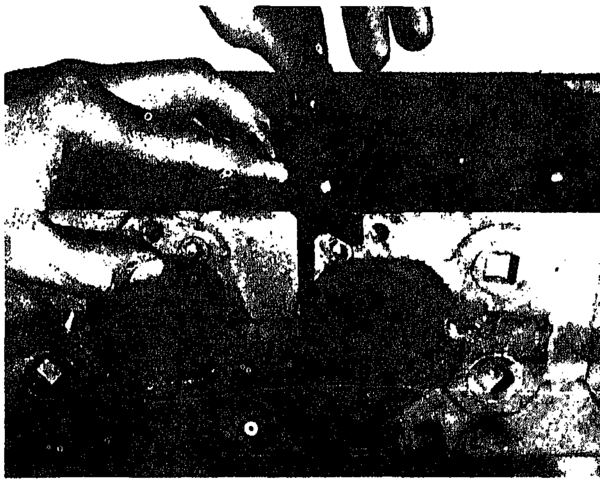


Fig. 2-1-13. Check cylinder head height N2

b. Install new injector sleeves to maintain correct injector protrusion. See Unit 202.

it is necessary to install spacers (1/16 in. [1.5875 mm] maximum) under springs to obtain correct assembled height.

Caution: Only 1/32 in. [0.7937 mm] spacer can be used if head has not been resurfaced.

Regroove Cylinder Head

Beaded cylinder liners, steel cylinder head gaskets and grooved cylinder heads are designed to operate in conjunction with each other.

If the cylinder head has been resurfaced or has not been grooved previously, it will be necessary to cut grooves in the cylinder head over each cylinder liner. These grooves will assure a better seal between the cylinder head gasket and block during engine operation. Fig. 2-1-14. Use ST-597 or ST-913 Cylinder Head Grooving Tool to perform this operation.

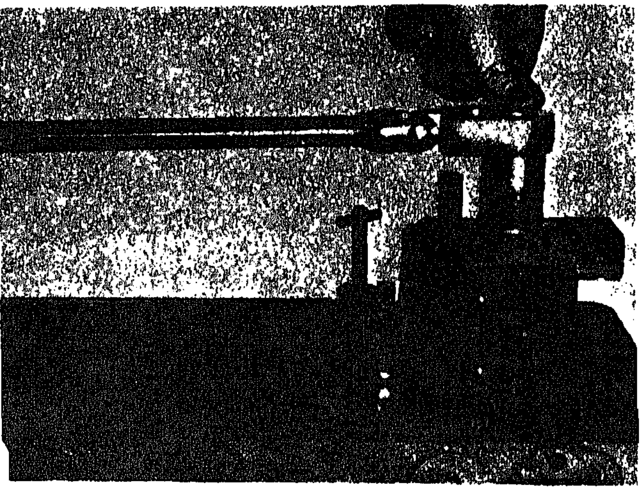


Fig. 2-1-14. Regroove cylinder head N20231

To use ST-597 grooving tool:

Place cylinder head in Head Holding Fixture.

Select scrapped injector, preferably one with Class "O" plunger bore and injector cup. Cut off cup exposing plunger bore, maintaining cup seal area intact. Install reworked cup on injector body.

Install injector and cup in cylinder head and secure at operating torque.

Select spacer block, Table 2-1-3, for bore size desired. Loosen two socket head screws in end of ST-597. Assemble spacer between pilot pin and tool holder blocks.

Position largest pilot pin so it protrudes down in same direction as cutter and tighten assembly in place.

Table 2-1-3: Regrooving Tool Block — In. [mm]

Engine Series	Thickness Spacer	Center of Pilot Pin to Center of Cutter
C	0.295 [7.4930]	2.543/2.547 [64.5922/64.6938]

f. Turn cylinder head upside down on head holding fixture and instal' ST-597 pilot pin into injector bore.

g. Check position of stop in tool holder block to assure it will not contact water hole during grooving operation.

h. Set stop on tool so cutter protrudes 0.006/0.008 in. [0.1524/0.2032 mm] below stop. Rotate tool clockwise to cut groove.

Caution: Do not attempt to cut deeper than cutter groove depth or cutter will break. Groove lands should be 0.010/0.015 in. [0.2540/0.3810 mm] wide and flush with head surface.

2. To use ST-913 grooving tool:

a. Place cylinder head in Head Holding Fixture.

b. Check data plate on housing to determine in which hole the locating plug is to be placed.

c. Place tool holder into slot in housing with locating plug in proper hole and secure with 5/8 in. [15.8750 mm] capscrew.

d. If tool has not been adjusted previously, adjust as follows:

(1) Place housing, with tool holder secured in place, on a surface plate or similar flat surface.

(2) Loosen setscrews holding tool adjusting screw and turn adjusting screw down until tool cutting bit touches surface plate.

(3) Remove grooving tool from surface plate and turn adjusting screw down three notches, or 60°, to lower cutting tool bit approximately 0.006 in. [0.1524 mm].

e. Install grooving tool on head by placing the locking screw in the injector holes and tighten hand tight. This locking screw can be used either with or without the injector sleeve.

Caution: Over-tightening of locking screw in head when injector sleeve has been removed may cause mutilation of the beads in the head.

f. Check head to assure cutting tool bit will not contact water hole during grooving operation.

g. Rotate grooving tool clockwise to cut groove. The tool bit is spring loaded in the tool holder and will ride over any "hard" spots on the head surface. It may take two or three revolutions to get a smooth even cut in the head. Fig. 2-1-14.

Injector Sleeve—Unit 202

1. Remove worn flange-mounted injector sleeves by cutting them from cylinder head with a 3/8 in. [9.5250 mm] gouge chisel (sometimes called a muffler sleeve cutting tool) and driving out from lower end.

2. Remove all foreign material from injector sleeve sealing area.

Machine bead in sleeve seat area of head, if not previously beaded, with Fig. 2-2-1. This will provide an improved seal.

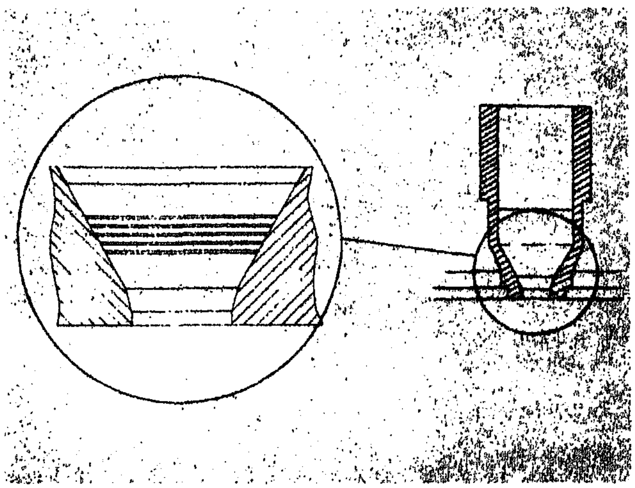


Fig. 2-2-1. Sleeve seat bead and chamfer location N20232

1. Install the bead cutter in Seat Cutter Holder and position with Cutter Pilot in a drill press. Set drill press speed at not more than 75 rpm. Cutter may be turned by hand using a tap wrench.

Caution: Chattering may occur if drill press speed is over 75 rpm.

2. Place cylinder head on drill press table, allowing clearance for the end of the bead cutter to protrude below the head surface into a pilot. The pilot can be made by recessing a 1/2 in. [12.7000 mm] drill bushing in a plate which is c tered below the drill spindle and secured in place.

3. Before starting drill press motor, insert cutter, adapter pilot into injector bore to insure proper alignment.

4. Lift cutter, adapter and pilot, lubricate cutter with cutt oil and start cutting operation, applying a steady moder pressure.

Caution: Do not cut more than 0.010 in. [0.2540 mm] de

5. When the proper depth has been obtained, allow the cu to dwell for approximately 10 seconds to insure a good s and clean grooves.

6. Lubricate and install Cutter, adapter and pilot. Attach a tap wrench to the adapter and rotate, app ing a light even pressure. The Cutter is used to a 30° angle chamfer at the lower edge of the 60° s When the upper end of the 30° angle chamfer is appr mately 9/64 in. [3.5718 mm] from the bottom bead, rem cutter, adapter and pilot.

7. Remove bluing from 60° seat.

Sleeve Installation

1. Drive in injector sleeve with injector sleeve dri Fig. 2-2-2.

2. Remove driver from injector sleeve and install inje

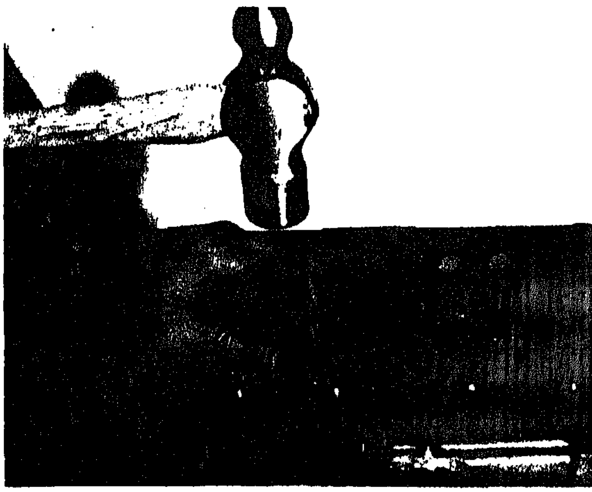


Fig. 2-2-2. Installing injector sleeve N

leeve holding tool

Seal upper portion of sleeves with expanding roller Fig. 2-2-3. Apply force to expand rollers until sleeve upper diameter reaches 1.375/1.380 in. [34.9250/35.0520 mm].

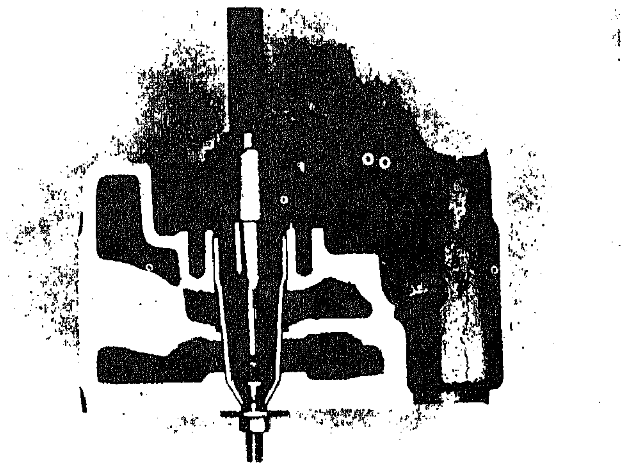


Fig. 2-2-3. Sealing upper end of injector sleeve N20214

Remove the injector hold down tool.

Seal injector sleeve in lower seating (tapered) area with Angle Roller Tool, Fig. 2-2-4.

With roller in drill press set at 250 rpm, apply 500/650 lbs. [226.7500/294.7750 kg] axial force for 30 seconds. Lubricate roller during this operation.

Cut injector seat to provide proper injector seat and injector tip protrusion. Use seating cutter and

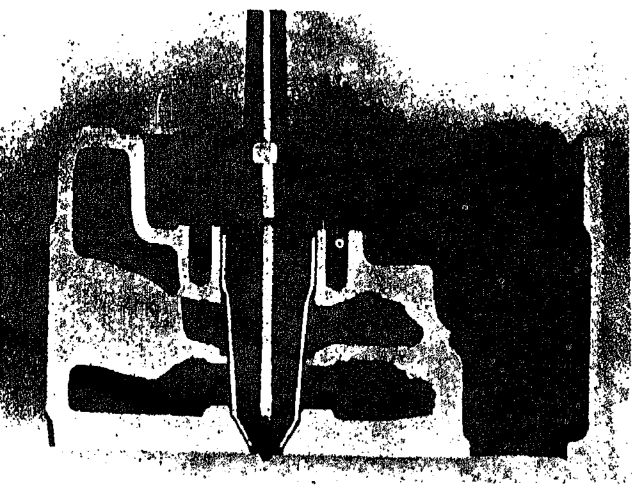


Fig. 2-2-4. Sealing lower end of injector sleeve N20215

pilot tool. It is very important that the cutter be ground to the exact dimensions shown in Table 2-2-1 and Fig. 2-2-5.

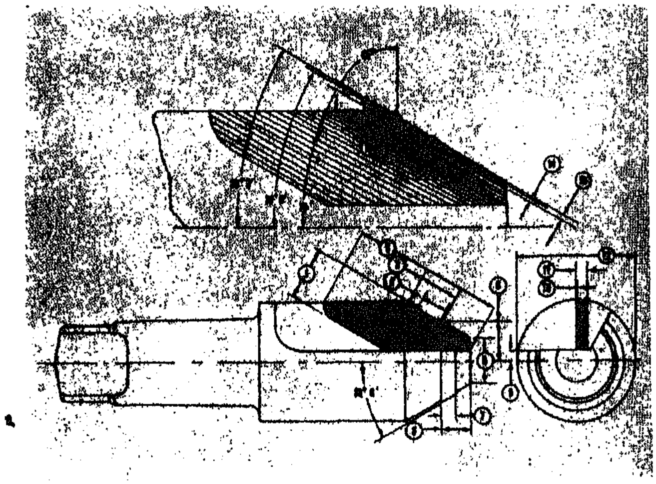


Fig. 2-2-5. injector seat cutter dimensions — Table 2-2-1 N20213

Table 2-2-1: Injector Seat Cutter Dimensions — In. [mm]

1. 0.250 [6.350]	6. 0.3125 [7.9375]	11. 0.0937 [2.3799]
2. 0.875 [22.2250]	7. 0.0937 [2.3799]	12. 0.923/.925 [23.4442/23.4950]
3. 0.3161 [8.0289]	8. 0.250 [6.350]	13. 0.0053/0.0073 [0.1346/0.1854]
4. 0.145/0.155 [3.6830/3.9370]	9. 0.0937 [2.3799]	14. 0.0015/0.0025 [0.0381/0.0635]
5. 0.300/0.310 [7.6200/7.8740]	10. 0.010 [0.254]	15. 0.040/0.060 R. [1.0160/1.5240]

Reference Fig. 2-2-5.

8. To determine amount of cut, install injector and measure tip protrusion. Depth of cut should provide 0.040/0.055 in. [1.0160/1.3970 mm] protrusion of injector cup tip beyond milled face of cylinder head. Maximum allowable injector cup protrusion is 0.065 in. [1.6510 mm].

Valve Seat and Insert—Unit 203

Valve Seat Insert

The valve seat insert is used to provide a greater wear-resistant surface than the cylinder head material and to provide a new seat where an insert was not used before.

1. Remove loose or excessively worn valve seat inserts, which were previously marked for replacement during cylinder head inspection, with an insert extracting tool or by striking insert sharply with a chisel, causing it to crack and release the press fit. Remove all inserts if head has been resurfaced. Fig. 2-3-1.

Fig. 2-3-1. Removing valve seat insert N20233

Caution: Cover the valve seat with a shop rag to avoid injury from broken pieces of the seat.

2. Enlarge counterbore to next oversize. Most inserts are available in standard and oversizes as shown in Table 2-3-1.

   Note: If head was resurfaced and inserts are to be reused, deepen counterbore only.

3. Valve Seat Insert Tool must be used to hold and drive cutters and must be driven by an electric motor. Fig. 2-3-2.

4. Cut counterbore 0.006/0.010 in. [0.1524/0.2540 mm] deeper than insert thickness to permit peening of head to hold insert.

5. Install valve seat insert and peen around insert in at least

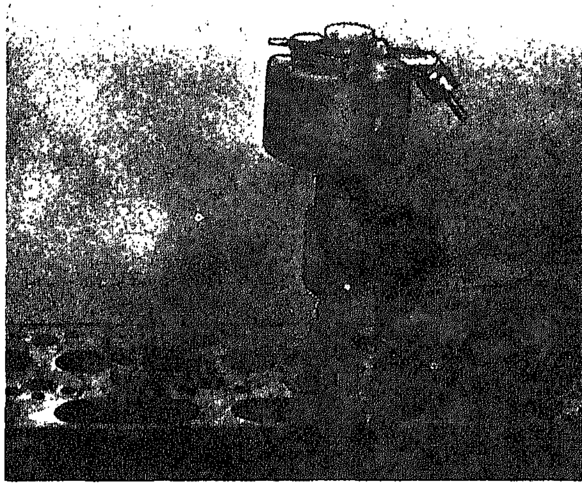


Fig. 2-3-2. Counterbore for valve seat insert

4 or 5 places with the peening tool
A 1/4 in. [6.3500 mm] diameter r
end punch may also be used.

Caution: Over-swagging around insert may crack cyli head.

Grind Valve Seats

1. Use Valve Grinding Kit (contains parts to valve seats).

2. Check condition of grinding equipment.

a. Mandrels must be straight and of proper size to fit in guides.

b. Bushings in grinder must be clean and must fit prope guide mandrel.

c. Drive unit bearings must be in good condition.

3. Dress stone to 30° from horizontal.

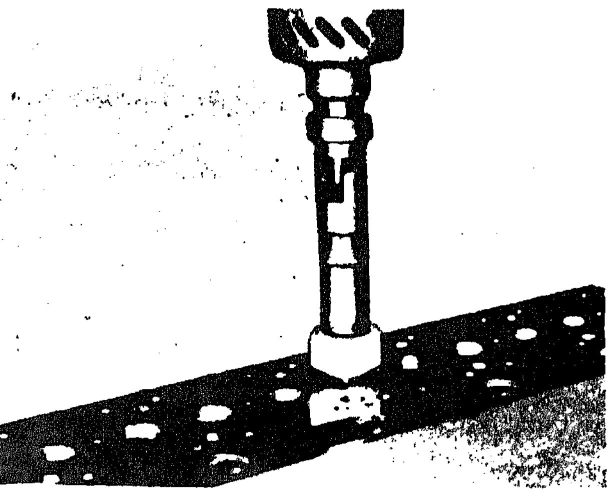
4. Grind valve seats, holding seating motor as nearly ve as possible. Fig. 2-3-3. A severe angle will cause se be out-of-true depending upon amount of wear in gr bearings, mandrel, bushings, etc., even though grinde a universal joint.

5. Check valve seat width which should be 1/16 to 1/ [1.5875/2.1750 mm]. See Fig. 2-3-4.

le 2-3-1: Valve Seat Insert Specifications — In. [mm]

gine ries	ST-257 and Following ST Cutters	Insert Part Number	Oversize Diameter	Depth	Insert O. D.	Cylinder Head I. D.	Insert Thickness
C our lves	ST-484	70843	Std.	Std.	1.4300/1.4305 [36.3220/36.3347]	1.427/1.428 [36.2458/36.2712]	0.156/0.161 [3.9624/4.0894]
r linder)		103331	0.010 [0.2540]	Std.	1.4400/1.4405 [36.5760/36.5887]	1.432/1.433 [36.3728/36.3982]	0.156/0.161 [3.9624/4.0894]
		103332	0.020 [0.5080]	0.005 [0.1270]	1.4500/1.4505 [36.8300/36.8427]	1.447/1.448 [36.7538/36.7792]	0.161/0.166 [4.0894/4.2164]
		103333	0.030 [0.7620]	0.010 [0.2540]	1.4600/1.4605 [37.0840/37.0967]	1.457/1.458 [37.0078/37.0332]	0.166/0.171 [4.2164/4.3434]
		103334	0.040 [1.0160]	0.015 [0.3810]	1.4700/1.4705 [37.3380/37.3507]	1.467/1.468 [37.2618/37.2872]	0.171/0.176 [4.3434/4.4704]

ution: Be sure to measure insert before machining head or installing insert in head.



. 2-3-3. Refacing valve seat N20216

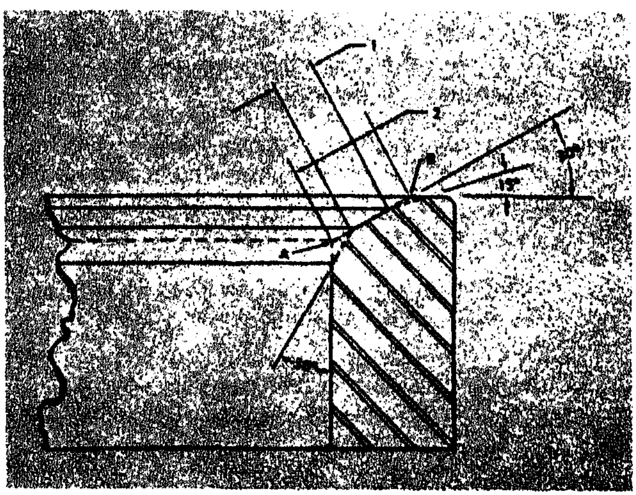


Fig. 2-3-4. Valve seat insert cross-section N10228

a. If seating area is wider than 1/8 in. [3.1750 mm] maximum, stock can be removed from points "A" and "B" with specially dressed valve seat grinder stones.

b. Narrowing should not extend beyond chamfer on seat insert. Chamfer provides for peen metal.

6. Dress wheel for final finish.

7. Finish grind with light touches of stone against face.

8. Check valve seat concentricity with valve seat indicator as shown in Fig. 2-3-5.

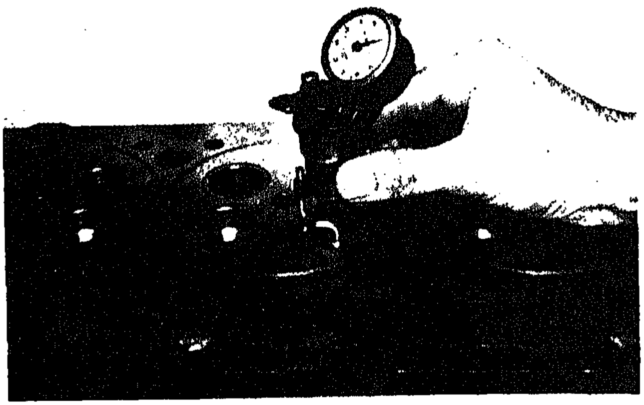


Fig. 2-3-5. Indicating valve seat insert N10229

a. Use valve guide as a center.

b. Total run out should not exceed 0.002 in. [0.0508 mm].

c. The gauge must be a perfect fit on pilot mandrel.

9. Check seat with mating valve as described on Page 2-5-3 to insure proper sealing.

Valve Crossheads and Guides—Unit 204

Valve Crosshead Guides

Valve crossheads are used on engines with dual intake and exhaust valves to insure that both valves under the crosshead are opened and closed at the same time.

1. Remove crosshead guides to be replaced, using Puller ' Fig. 2-4-1.

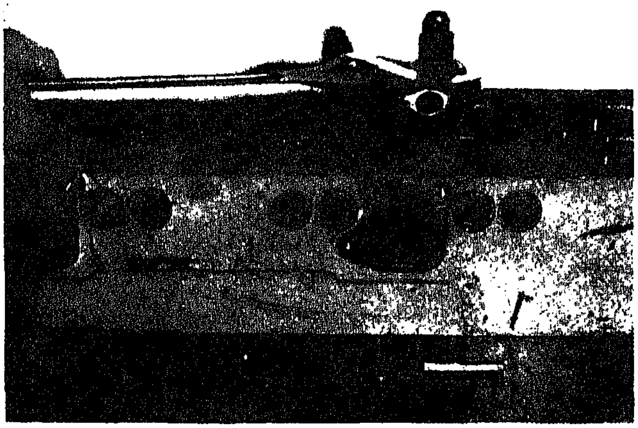


Fig. 2-4-1. Pulling crosshead guide N20234

2. Press in new solid guides to 1.540/1.550 in. [39.1160/39.3700 mm] assembled height. Fig. 2-4-2.

Note: Current cylinder heads are equipped with "solid" pin-type crosshead guides and crossheads with hollow stems. Old-and new-style crossheads and guides may be used in the same cylinder head.

Type Crosshead	New Minimum	New Maximum	Worn Limit
Solid Stem	0.3708 [9.4183	0.3713 [9.4310]	0.370 [9.3980]
Tubular Stem	0.376 [9.5504]	0.378 [9.6012]	0.380 [9.6520]

Table 2-4-1: Crosshead Dimensions — In. [mm]

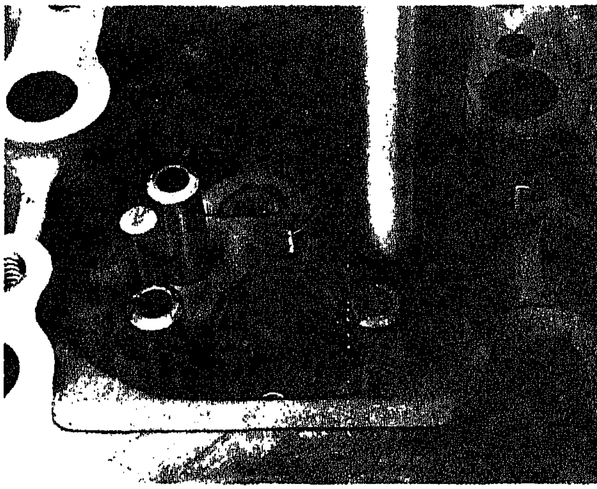


Fig. 2-4-2. Installing crosshead guide N2

3. If mandrels are not available, press guides into head obtain above protrusion.
4. Crosshead tubular guides should be pressed in head 1.420/1.440 in. [36.0680/36.5760 mm] protrusion.
5. Use conversion guide (116139) to replace tubular gui with solid guides. This guide can also be used for salv purposes if the solid-type guide hole requires rean oversize.

Crossheads

Tubular Stem Crosshead

1. Clean crossheads.
2. Check for cracks with Magnaflux process.
3. With accurate micrometers, set a small bore gauge 0.0002 in. [0.0050 mm] above worn placement limit. Use as a "No-Go" gauge in crossh bore to check for wear beyond worn replacement lir shown in Table 2-4-1. Check for out-of-round holes.
4. Gauge hole at several points 90° apart.

Caution: Do not use a plug gauge for this operation.

5. Check reamed depth of crosshead bore; it should b minimum of 1.370 in. [34.7980 mm] in depth.
6. Check valve stem counterbore depth in underside of cr

ead; it should be a minimum of 0.090 in. [2.2860 mm] deep.

Mark crossheads for replacement that are not within worn replacement limits.

Check for excessive wear on rocker lever and valve contact surfaces.

Solid Stem Crosshead

Repeat Steps 1 and 2 above.

Measure crosshead O.D. with micrometers. Mark for replacement if wear exceeds limits shown in Table 2-4-1.

Note: When replacement is necessary it is suggested that the crosshead guide and crosshead both be changed. Step under "Valve Crosshead Guides" preceding.

Repeat Step 8 above.

Valves, Guides and Springs—Unit 205

Inspect Valves

Stellite-faced exhaust valves can be identified by letters "EX" or "SF" in the recessed area of the valve head.

Visual Method

Inspect, then discard if:

1. Heads are cupped, cracked, pitted or worn too thin to regrind within limits. Check valve head rim thickness (A, Fig. 2-5-1); it should be a minimum of $\frac{1}{16}$ in. [1.5875 mm].

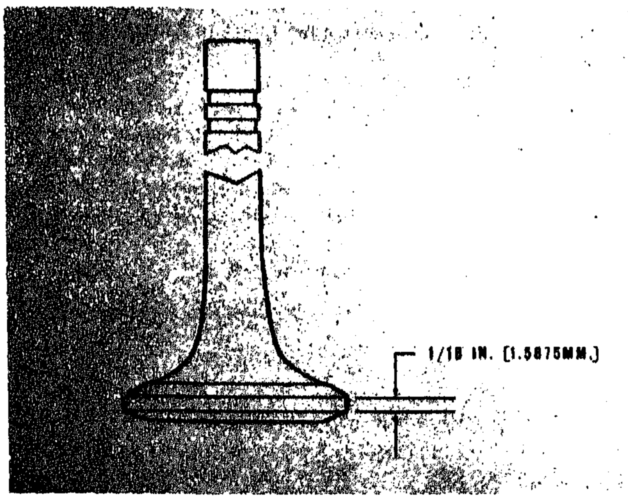


Fig. 2-5-1. Minimum valve head rim thickness N10231

2. Stems, Fig. 2-5-2, are scored or worn beyond worn limits shown in Table 2-5-1.

Table 2-5-1: Valve Stem Dimensions — In. [mm]

Engine Series	New Minimum	New Maximum	Worn Limits
C (Four valve)	0.3400 [8.6360]	0.3410 [8.6614]	0.3390 [8.6106]

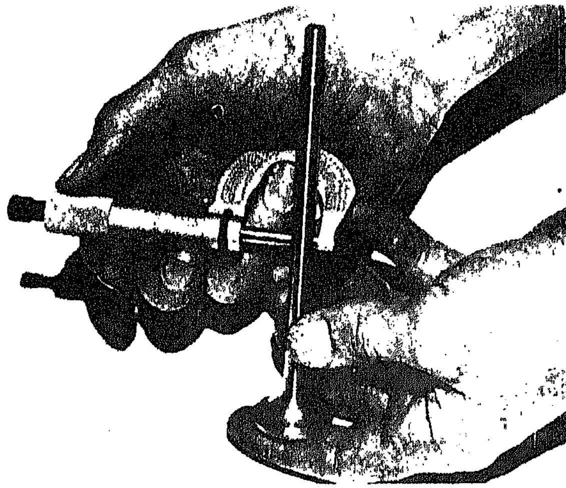


Fig. 2-5-2. Measuring valve stem N20

3. Collet recesses are worn so new collets will not fit s curely in recesses.

Grind Valves

Use Valve Grinding Kit

1. Check valve grinder setting by using a new valve and indicator gauge.

a. Chuck valve on guide area of stem. Fig. 2-5-3. Reliev portions on both ends of guide area are not necessa concentric to guide area of stem.

b. Indicate on ground face of valve.

c. Turn valve and mark high spot on head of valve.

d. Rechuck the valve 180° from first position.

e. Repeat (b) and (c). If high spots are same for both (a) a (d) positions, valve is warped. If high spots occur in c ferent positions, chuck is out of alignment. Runout shou not exceed 0.001 in. [0.0254 mm].

2. Check bearings of machine.

3. The grinding wheel must be the proper grade and prope dressed to avoid chatter and grind marks.

4. Wet-grind valves to an exact 30° angle from horizontal

5. Valves and seats properly ground with precision equ ment should not require lapping to effect an air-tight se

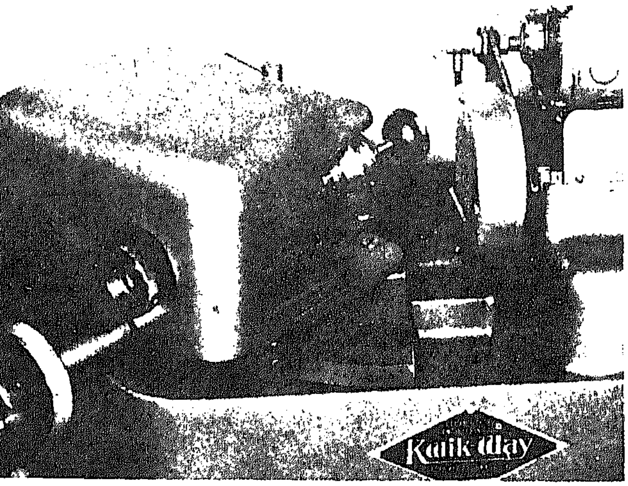


Fig. 2-5-3. Valve grinding V10230

however, a small amount of lapping is permissible if necessary in order to pass vacuum test described under "Testing Valve Seating" in following paragraphs.

Check rim thickness as shown in Fig. 2-5-1. If rim is less than 1/16 in. [1.5875 mm], valve is not suitable for use because of danger of burning and cupping.

Check valve in a finish-reamed guide and against a newly ground valve seat face. Pencil mark valve and drop into position; rotate valve 10°. A good seat will be indicated if all pencil marks are broken. Fig. 2-5-4. If pencil marks are not broken, valve seat tools need dressing or machine has not been properly adjusted; final check should be made with a vacuum tester. See "Testing Valve Seating".

Conditions of a good valve seat.

No grinding or reamer marks on seating surfaces and within guide.

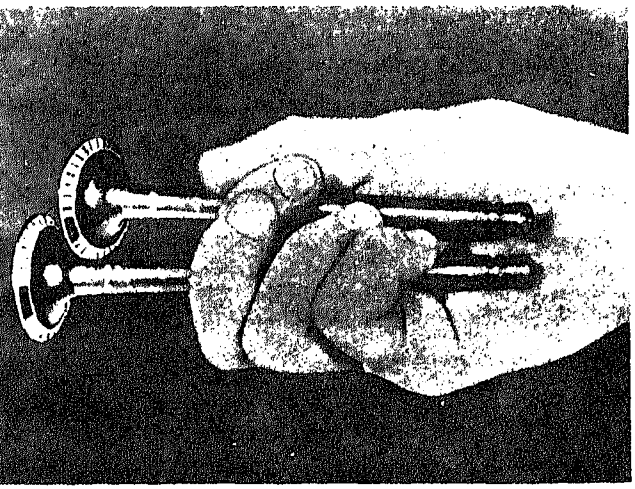


Fig. 2-5-4. Pencil marks on valves N20217

b. Valve face a true 30° angle.

c. Width of grind is within limits.

d. Guide-to-stem clearance is within limits as determined from dimensions shown in Table 2-5-1 and Table 2-5-2.

Table 2-5-2: Valve Guide Inside Diameter — In. [mm]

Engine Series	Reamer	New Minimum	New Maximum	Worn Limit
C, (4 Valve)	ST-478	0.3425 [8.6995]	0.3432 [8.7172]	0.3442 [8.7426]

Valve Guides

Inspect Guides

1. A plug gauge is not satisfactory to gauge worn holes. It will not detect an out-of-round hole. Instead, use a small bore gauge.
2. To use a small bore gauge, set it with accurate micrometers at 0.0002 in. [0.0050 mm] larger than worn replacement limit shown in Table 2-5-2. Then use bore gauge as a "No-Go" gauge. Fig. 2-5-5. Gauge the hole at several points crosswise and endwise of head.

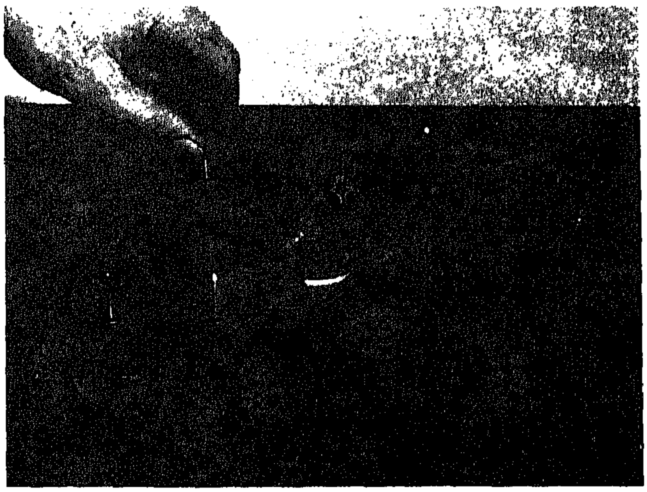


Fig. 2-5-5. Measuring valve guide N20235

3. If old valve guides are worn beyond worn replacement limits shown in Table 2-5-2, mark for replacement.

4. Inspect the sharp edge of tapered valve guides for chips, cracks, burrs; if damaged, mark for replacement.

Replace Valve Guides

1. Drive out worn guides from underside of cylinder head.
2. Install new guides with arbor press and proper mandrel. Fig. 2-5-6. Refer to Table 2-5-3 for proper mandrel.

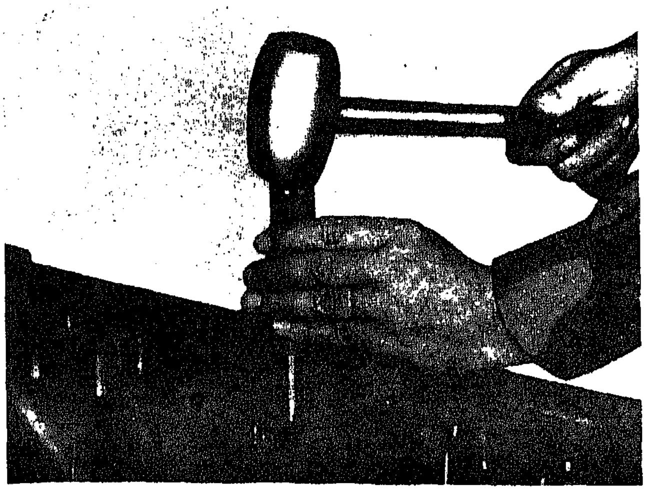


Fig. 2-5-6. Installing valve guide N20210

Table 2-5-3: Valve Guide Protrusion — In. [mm]

Engine Series	Mandrel	Protrusion
C (4 valve)	ST-740	1.240/1.260 [31.4960/32.0040]

3. If proper valve guide mandrels are not available, press guides into head to obtain protrusion above head surface as listed in Table 2-5-3.
4. Most valve guides will not require reaming. Insert valve into guide and check for freedom of movement, or check guide with small bore gauge to determine if guide bore is too small.

Caution: Guides which have been through the "tuff-riding" process, identified by a dull grey appearance, are not to be reamed.

5. If reaming is necessary proceed as follows:

a. Ream valve guide from bottom side of cylinder head, using a drill press and floating tool holder. Fig. 2-5-7.

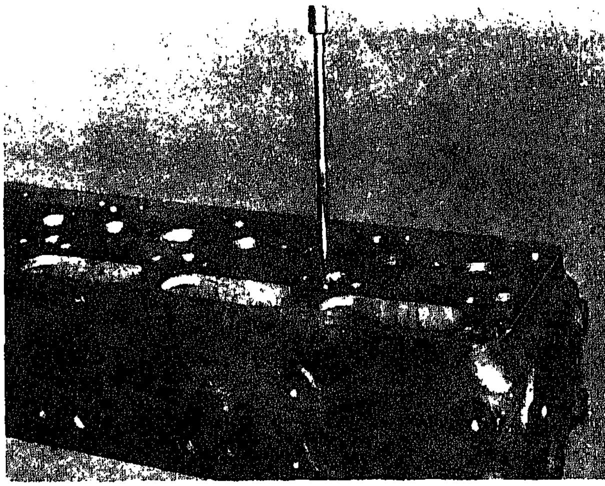


Fig. 2-5-7. Reaming valve guide N20

Note: Use lubricating oil or soluble oil and water solut for good finish.

b. Ream valve guides with proper reamer to dimensions sho in Table 2-5-2.

Caution: Special care must be used to avoid breaking c bide tips. Sharpen tipped tools on a diamond-impregna wheel.

Valve Springs

Weak valve springs may cause valve flutter which resu in excessive wear on both valve and seat. Valve flutter terferes with valve timing and may cause valve to strike piston head. Valve warping, cracking and breaking are results of weak valve springs.

1. Test valve spring on spring tester that is capable of v accurate measurements of spring lengths by means standards as listed in Group 16 and dial indicator gau Fig. 2-5-8.
2. One spacer may be used under valve spring when ins and valve have been refaced to make valve check wit load limit. Refer to parts catalog for specific spacer pe nent to engine model.

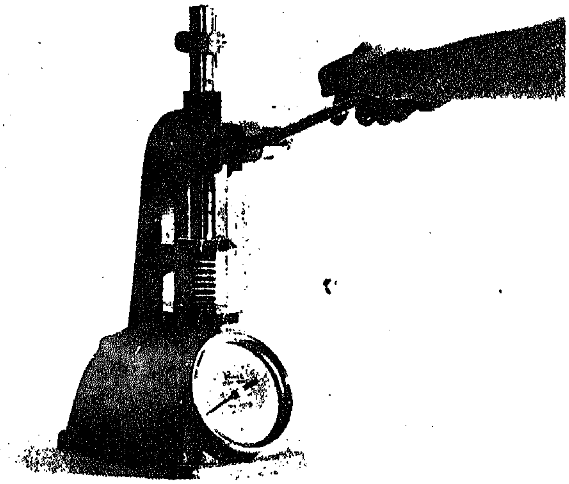
Note: A maximum of $\frac{1}{16}$ in. [1.5875 mm] spacers may used under valve spring when head has been resurfa and valve and seat have been refaced.

3. If valve springs compress to dimension shown, at less t load indicated under "worn limits", valve springs should discarded. Table 2-5-4.

2-5-4: Valve Spring Data — In. [mm], lb. [kg]

e s	Valve Spring Part No.	Approximate Free Length	No. Coils	Wire Dia.	Length	lb. [kg] Required to Compress New Minimum	New Maximum	Worn Limits
4	*106664	2.539 [64.4906]	10½	0.148 [3.7592]	1.673 [42.4942]	116 [52.6060]	128 [58.0480]	105 [47.6175]
5	*120089	2.364 [60.0456]	9½	0.148 [3.7592]	1.610 [40.8940]	105 [47.6175]	117 [53.0595]	100 [45.3500]

ion: Do not mix valve springs of different lengths under the same crosshead.



5-8. Testing valve spring V10214

Assembly and Testing

Assembly of the head at this stage is complete except valve installation. After all parts are installed, test to make sure head is ready to place into operation.

Assembly

Clean cylinder head, valves, springs, etc. before assembling. Check parts list to determine correct valve and piston combination. Some pistons cannot be used with current intake valves without causing piston and valve contact.

1. Insert valves.
2. Place cylinder head face down on a wooden bench or protective surface to prevent marring milled surface.
3. Assemble lower valve spring guides on valve guides.
4. Assemble springs.

Notes:

a. Use same part number spring with mating spring under crosshead.

b. Reground valve heads seat deeper in cylinder head causing valve stem to protrude further above the guide. This allows valve spring to extend beyond length limits and causes weak spring action. Therefore, up to $\frac{1}{16}$ in. [1.5875 mm] of spacers may be used to reduce valve spring length.

Caution: Too many spacers will cause the compressed spring to become a solid sleeve. See Table 2-5-4, "Valve Spring Data."

5. Assemble upper valve spring guide.
6. Use Valve Spring Compressor to compress valve spring. Insert new half-collets.

Testing

Valve Seating

A vacuum tester to check valves and seats for leakage is available. It consists of a vacuum pump, vacuum gauge and vacuum cup. Use with any 6-volt battery source or 110-volt electrical outlet as required. Fig. 2-6-1.

Caution: Never vacuum test cylinder head with injectors installed.

1. Valves and seats must be dry and clean.

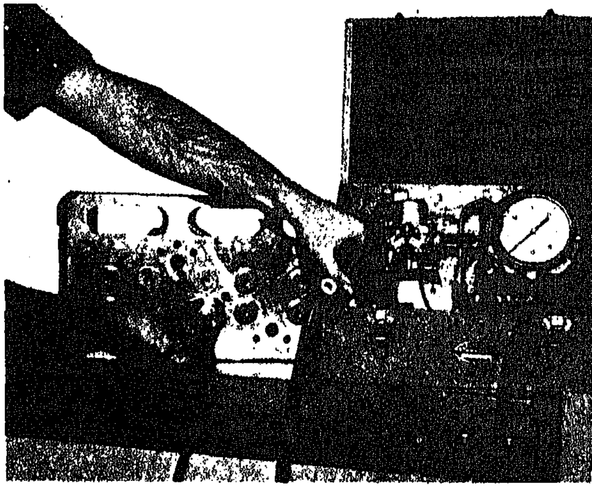


Fig. 2-6-1. Vacuum testing valves for leaks N

2. Select proper vacuum cup (1, Fig. 2-6-1) for size valve be tested. Cups are furnished with each tester so all gine models can be tested.
3. Place vacuum cup over valve head. "O" ring on cup sh seat on flat surface of head surrounding valve. Grease be applied to "O" ring for a better seal.
4. Turn hand shut-off valve to open position; hold push ton (2) to operate vacuum pump.
5. Operate vacuum pump until hand on vacuum gauge stops climbing at 18 to 25 inches of mercury as shown dial.
6. Close shut-off valve (4); release push button to stop pu
7. Time fall of gauge hand to test valve seat.

a. Begin timing as soon as hand reaches "18" on dial.

b. Stop timing when hand reaches "8". If elapsed time is than ten seconds, valve seat seal is unsatisfactory.

8. Tap the stem end of the valve with a soft-faced mallet retest.
9. If valve seat is unsatisfactory:

a. Check for leaking connections in tester; operate vac pump with suction cup against a clean window glass or smooth flat surface; check for fall of indicator hand i cating loose connection.

b. Make sure valve and seat are not dirty.

{egrind valve and seat if necessary; however, it is possible o mistake leakage around the valve seat insert for valve eat leakage. If this type of leakage is suspected, apply jrease around outside edge of insert to make a grease eal. Perform vacuum test and inspect the grease seal for break indicating air leakage between wall of counterbore ınd valve seat insert. If leak around valve seat insert is ound, correction is required before continuing with test.

Vate. Test

{eplace all pipe plugs if not in place. Use sealing tape or ead sealer to prevent leakage. Torque plugs to values listd in Table 2-6-1.

able 2-6-1: Cylinder Head Pipe Plug Torque Ft.-Lb. [kg m]

Plug Size	Minimum	Maximum
⅛ In.	5 [0.6910]	10 [1.3820]
'use Plug	5 [0.6910]	10 [1.3820]
⅜ In.	35 [4.8370]	45 [6.2190]
½ In	60 [8.2920]	70 [9.6740]
¾ In.	65 [8.9830]	75 [10.3650]
in.	135 [18.6570]	145 [20.0390]

nstall Injector Sleeve Holding Tool or a crap injector and cup assembly in each injector sleeve.

ighten sleeve holding tool to 10/12 ft.-lb. [1.3820/1.6584 kg n] to seal lower end of injection sleeve, Fig. 2-6-2, or intall injectors and secure with canscrews torqued to same alue.

est cylinder heads for leaks at 35/85 psi [2.4605/5.9755 kg/q cm] and, if possible, at 175°/200° F. [79°/93° C.] water emperature. Check carefully around valve seats and inector sleeve seats for any cracks, even though such cracks night not show water leakage. This type crack is caused vhen injector capscrews are tightened beyond factory orque recommendation. Discard head, if cracked.

)pen water outlet valve of test fixture; check for free water circulation through cylinder head. If restriction is evident, remove plugs and injector sleeves; clean water ackets of salt, lime or sludge.

ent Holes

ylinder head contains vent or breather holes that must be plugged on supernarged engines. Fig. 2-6-3.

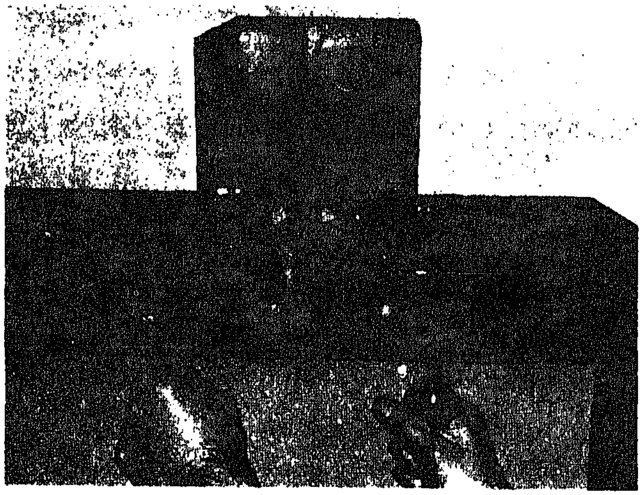


Fig. 2-6-2. Installing injector sleeve holding tool N20237

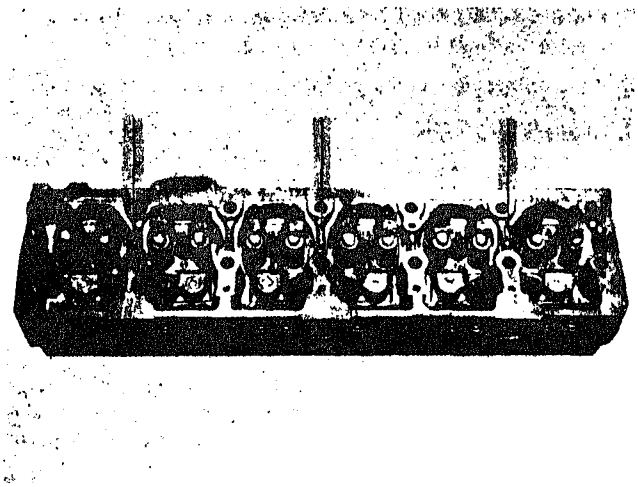


Fig. 2-6-3. Vent holes N20224

Rocker Lever Group

The rocker lever group consists of rocker levers,
tubes, cylinder head covers and crankcase breathers.

Rocker Levers and Cover—Unit 301

Measurements

All dimensions in this group are listed in both U.S. and Metric units. The metric units are enclosed in brackets [ ].

Rocker Lever Disassembly

1. Slide rocker lever shaft bearings and rocker levers off rocker lever shaft.
2. Remove adjusting screw locknuts and adjusting screws from rocker levers.

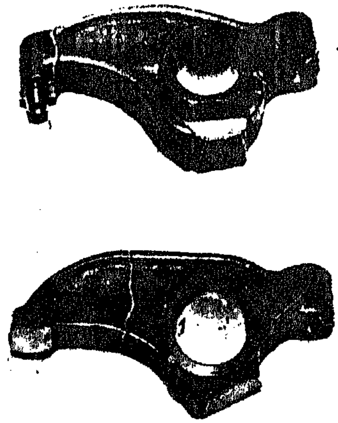


Fig. 3-1-1. Magnetic inspection crack indication

Cleaning and Inspection

1. Clean all parts in cleaning solvent.
2. Blow out lubricating oil passages with compressed air.
3. Check for surface imperfections by magnetic inspection. Apply coil magnetization, amperage at 300 to 500 with residual Magnaglo. See Fig. 3-1-1 for most likely areas.
4. The ball end of rocker lever adjusting screw must be a true sphere. Test with 1/4 in. [6.3500 mm] radius gauge. Replace if flat at bottom or there is evidence of scratching or galling. Fig. 3-1-2.
5. Examine injector rocker lever sockets for a true fit on injector links. Check sockets with a radius gauge or by observation of a small protrusion at bottom of socket. Pull *and discard damaged or badly worn injector rocker lever* sockets. If socket is broken press out by drilling a small hole in lever above socket; after socket is removed, weld hole closed or install and stake plug in hole.
6. Check rocker lever bushings for scratches, pitting or scoring. Check rocker lever bushing inside diameter with in-

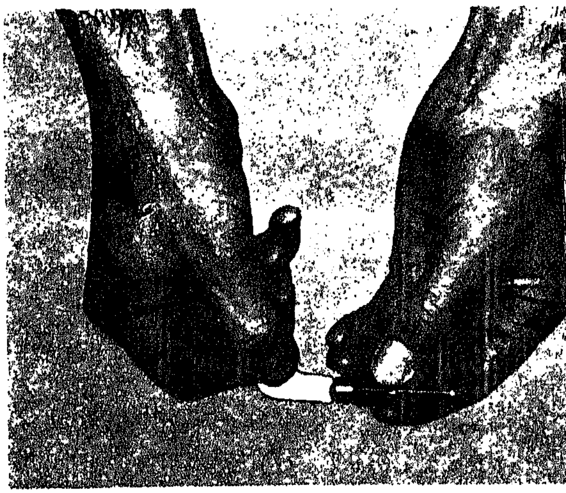


Fig. 3-1-2. Checking rocker lever adjusting screw ball end

7. If steel bushing exceeds 1.1275 in. [28.6385 mm] pre

Check intake and exhaust rocker lever valve contact surfaces. If worn or damaged, grind to original contour or replace with new rocker lever.

Check rocker lever shaft for wear or scoring. If shaft has shoulders or ridges due to rocker lever action on shaft, replace with new rocker lever shaft.

Examine rocker lever shaft bearings for cracks, breaks and stripped threads. Replace as necessary.

Visually check surfaces which mate with adjacent levers. If galled, restore surfaces to original smoothness.

able 3-1-1: Rocker Lever Bushing Inside Diameter

Bushing Material	New Dimension Minimum In. [mm]	Maximum In. [mm]	Worn Limit In. [mm]
Steel	1.1245 [28.5623]	1.1275 [28.6385]	1.1285 [28.6639]

able 3-1-2: Rocker Lever Shaft Outside Diameter

New Dimensions Minimum In.	[mm]	Maximum In.	[mm]	Worn Limit In.	[mm]
1.1230	[28.5242]	1.1235	[28.5369]	1.1220	[28.4988]

Assembly

If rocker lever bushings were found unserviceable, press out (1, Fig. 3-1-3). Align oil hole in precision steel bushing (2) and oil hole in rocker lever and press bushing in. Locate bushing so split is not at bottom or load area in lever. Check lever over shaft to make sure bushing has not "collapsed".

Rocker lever assembly is lubricated through oil holes in shaft and in center bearing which indexes with oil passage in block. Oil line dowel pin in cylinder head indexes with center bearing.

Note: If new rocker lever shaft is being used, install new steel bushings in all rocker levers. Old-style bronze bushings will wear quickly and fail with new rocker lever shaft which has oil holes on the bottom; these bushings are no longer available as service parts.

Install dowels in end rocker lever shaft bearings.

Install rocker lever socket in injector rocker levers.

Install adjusting screws and locknuts in rocker levers.

Coat rocker lever shaft with clean lubricating oil.

Position an end rocker lever shaft bearing on gear case end (1, Fig. 3-1-4) of rocker lever shaft.

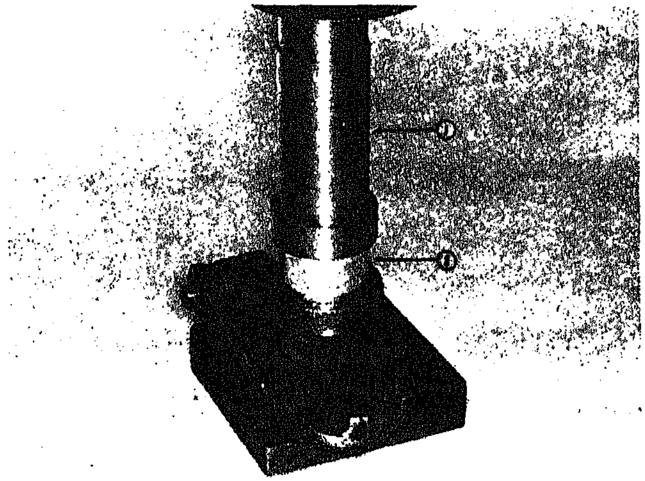


Fig. 3-1-3. Installing bushing N20306

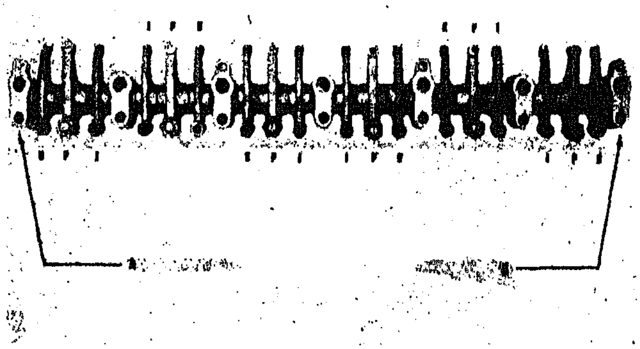


Fig. 3-1-4. Rocker lever assembly N20307

7. From opposite end of shaft, slide an exhaust (E), injector (F), and intake (I) rocker lever down against bearing.

8. Slide a plain bearing, an intake, injector and exhaust rocker lever onto shaft and against levers previously assembled.

9. Slide a bearing, tapped to receive a rocker lever cover capscrew, onto shaft.

10. Install an exhaust, injector, and intake lever and center bearing on shaft.

11. Install an intake, injector, and exhaust lever and another tapped bearing on shaft.

12. Install an exhaust, injector, intake lever, and plain bearing on shaft.

13. Install an intake, injector, exhaust lever, and remaining bearing on flywheel end (2) of shaft.

Cylinder Head Covers

Disassembly

1. Remove lubricating oil filler cap (3, Fig. 3-1-5.).

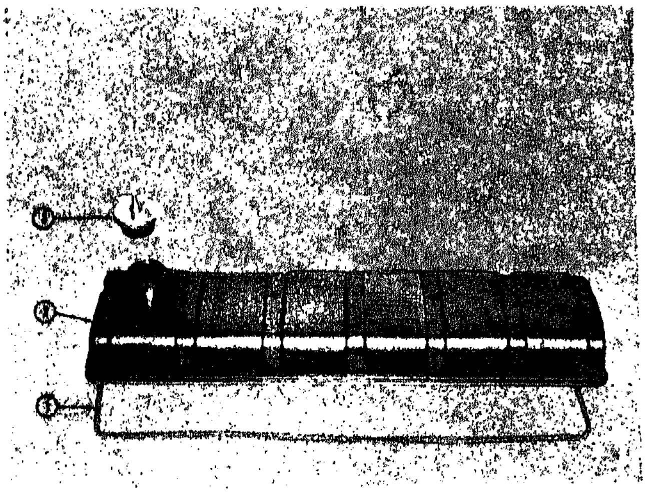


Fig. 3-1-5. Cylinder head cover assembly N20308

2. Remove crankcase breather element See Fig. 3-3-1.

3. Remove vapor tube, when used.

Cleaning, Inspection and Repair

1. Clean all parts except element in an approved cleaning solvent and dry with moisture-free compressed air.

2. Remove all gasket material from sealing edge of cover.

3. Inspect cover for cracks, dents and distorted sealing area; discard unserviceable parts.

4. ... except on sealing area.

Assembly

1. Install clean breather element, as used.

2. Install new or usable filler cap.

3. Reconnect vapor tube, when used.

Push Tubes—Unit 302

Each cylinder has an exhaust, injector, and intake push tube.

1. Clean push tubes in mineral spirits or equal solvent.
2. Check injector and valve push tube ball end with radius gauge for wear. Fig. 3-2-1.

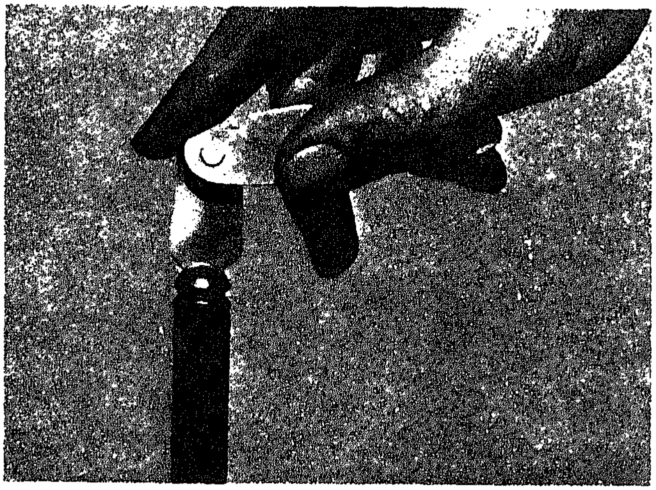


Fig. 3-2-1. Checking push tube ball end with radius gauge N20309

a. Ball end diameter, intake and exhaust push tube: 0.623/0.625 in. [15.8242/15.8750 mm].

b. Ball end diameter, injector push tube: 0.685/0.687 in. [17.3990/17.4498 mm] with 1/8 in. [3.1750 mm] diameter flat at bottom.

3. Check socket of push tube with ball end of a new rocker lever adjusting screw, Fig. 3-2-2, or with a 1/2 in. [12.7000 mm] check ball which should "blue in" 80% of seat area; spherical inside diameter new is 0.4995/0.5005 in. [12.6873/12.7127 mm].
4. Extreme wear on either end of push tube will result in loss of lubricating oil pressure and may interfere with correct injector and valve adjustment.
5. Check push tubes to see if they are bent (out-of-round). Tubes should not be out-of-round more than 0.025 in. [0.6350 mm], when located in centers of socket and ball. Push tubes that are bent have usually had the adjusting screws over-torqued.
6. Push tubes with worn balls should never be installed in new

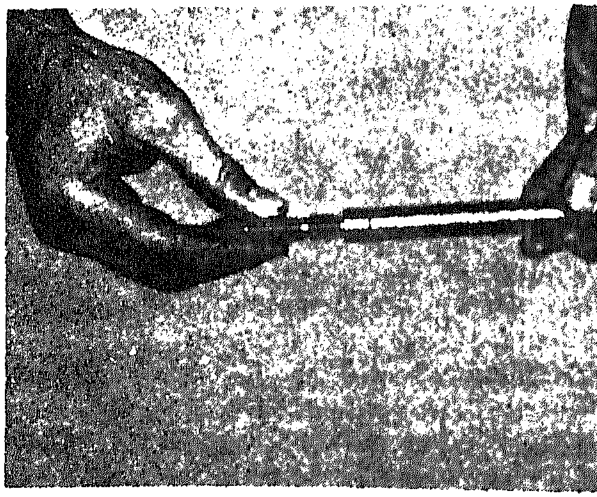


Fig. 3-2-2. Checking push-tube socket end with adjusting scre

7. Push tubes which have become filled with lubric should be drained by drilling a 1/16 in. [1.5875 mm] the tube 1 in. [25.4000 mm] above where tube cont insert.

Crankcase Breather—Unit 303

Screen Element Breather

The screen element type breather Fig. 3-3-2 is used on supercharged engines.

Remove capscrews, washer, cover (1, Fig. 3-3-2), screen (3), and baffle (4) from the breather body (5).

Remove the vent tube.

Clean vent tube, screens and baffle in an approved cleaning solvent. Dry with compressed air. Wipe out breather housing.

Assemble baffle (4), screens (3), and new gasket (2) in body (5).

Replace cover (1) with cover boss resting securely on point of screen secure with washers and capscrews.

Replace the vent tube.

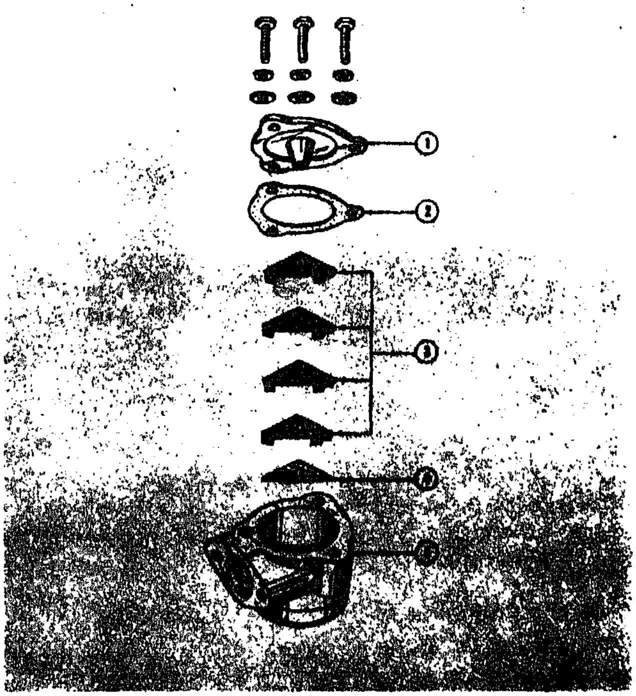


Fig. 3-3-2. Crankcase breather — screen-type element N20312

Tappets Group

Tappets are used to transmit movement from the eng camshaft to the push tubes and rocker levers to actu the injectors and valves. Tappet assembly is made up o body containing a push tube seat, a roller and pin; roller rides on the camshaft lobe.

Tappets—Unit 401

Measurements

All dimensions in this group are listed in both U.S. and Metric units. The Metric units are enclosed in brackets [ ].

Disassembly

1. Place 0.006 in. [0.1524 mm] shim between tappet (2, Fig. 4-1-1) and side of roller (3) to prevent springing fork when removing roller; press on end of pin (4) that is not lockwired (pinned).
2. Discard pin (4) and lockwire (5).

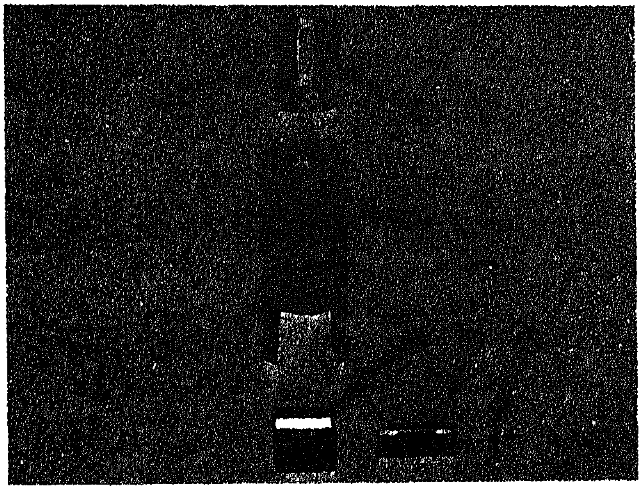


Fig. 4-1-1. Tappet exploded (sleeve-body-pin roller-wire) N20404

Inspection

1. Check for scored, flaked or chipped rollers; discard damaged parts.

Note: If any of the conditions above exist, camshaft should

2. Measure tappet body outside diameter for wear; meas roller outside diameter and inside diameter for wear. D card if worn beyond limits shown in Table 4-1-1.
3. Check tappet push tube seat by "bluing" correspond new push tube on ball end and rotating in tappet; a seat should be indicated. For best results keep push tu with mating tappet, especially if they are to be re-usec
4. Check body pin holes and inspect hole for burrs bef reassembly.
5. Check force required to move guide sleeve inside tapp if less than 15 in.-lb. [0.1725 kg m], install new sleeve.

Assembly

1. Insert 0.006 in. [0.1524 mm] shim between side of roller Fig. 4-1-1) and tappet (2); press pin (4) through tappet roller with lockwire (5) in pin. Make sure lockwire seats groove of tappet. See Fig. 4-1-2.

Caution: Lubricating oil passage in pin and tappet m index for adequate lubrication.

2. Install steel sleeve (1, Fig. 4-1-1) in tappet by compress and aligning guide slot in sleeve with slot in tappet bo

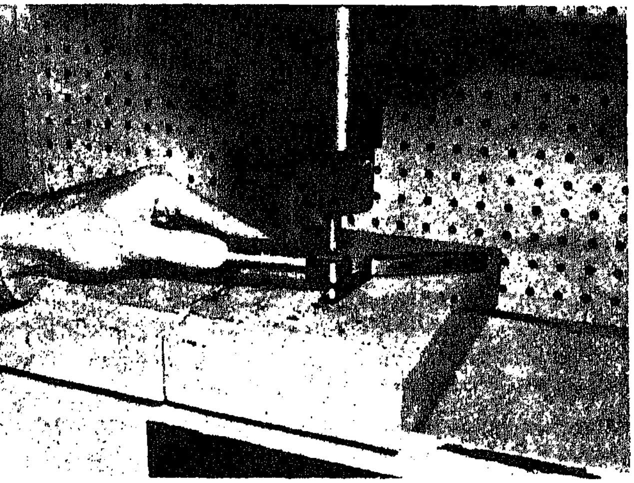
Caution: Make certain that any roller pins removed are placed with identical pins. Use of incorrect pin and tap combination will seal off lubricating oil drillings and le to parts failure. There are two styles of tappets and tap roller pins used in C and J Series Engines.

Inspection Of Assembled Tappet

Inspection of tappet assembly requires a surface pl small V block with clamp to hold tappet in position and indicator calibrated in tenths of a thousandth in. or [n attached to a surface gauge.

1. Using a small wire check indexing of pin and body lu

ssembly or part	New Minimum		New Maximum		Worn Limit	
ıjector Tappet						
ody Outside Diameter	1.3100	[33.2740]	1.3110	[33.2994]	1.3090	[33.2486]
oller Outside Diameter	1.1230	[28.5242]	1.1250	[28.5750]	1.1210	[28.4734]
oller Inside Diameter	0.5655	[14.3637]	0.5665	[14.3891]	0.5675	[14.4145]
oller Pin Outside Diameter	0.5620	[14.2748]	0.5626	[14.2900]	0.5610	[14.2494]
oller Side Clearance	0.0050	[0.1270]	0.0170	[0.4318]	0.0220	[0.5588]
oller Concentricity Assembled	—	—	0.0005	[0.0127]	—	—
oller Squareness Assembled	—	—	0.0010	[0.0254]	—	—
'alve Tappet						
ody Outside Diameter	1.1850	[30.0990]	1.1860	[30.1244]	1.1840	[30.0763]
oller Outside Diameter	1.0610	[26.9494]	1.0630	[27.0002]	1.0590	[26.8986]
oller Inside Diameter	0.5030	[12.7762]	0.5040	[12.8016]	0.5050	[12.8270]
oller Pin Outside Diameter	0.4995	[12.6873]	0.5000	[12.7000]	0.4985	[12.6619]
oller Side Clearance	0.0080	[0.2032]	0.0220	[0.5588]	0.0270	[0.6858]
oller Concentricity Assembled	—	—	0.0010	[0.0254]	—	—
oller Squareness Assembled	—	—	0.0010	[0.0254]	—	—



ig. 4-1-2. Installing tappet roller and pin N20402

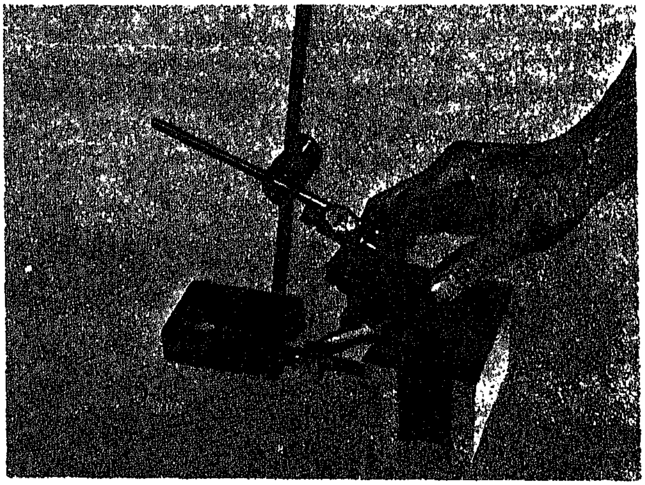


Fig. 4-1-3. Checking tappet roller concentricity N20405

Check freeness of roller by rotating two or three turns. If a "drag" is felt the plating on pin has probably picked up during assembly, due to burrs or pin not being held square during assembly.

Stand small V block on surface plate.

Note: *Tools and parts must be clean to obtain a true check.*

Stand tappet assembly on surface plate with roller up. Secure tappet in V block with clamp.

Using an indicator calibrated in tenths of a thousandth in. or [mm] check concentricity by rotating roller. Move indicator stand slightly and recheck. See Table 4-1-1 for dimensions.

Caution: Injector and valve tappet dimensions are not the same. Use correct dimensions when checking wear. Any parts that do not pass the checks must be disassembled. (Perform inspection during disassembly to determine the reason for rejection.) Reassemble tappets following "Assembly" and "Inspection of Tappet Assembly".

6. Using same indicator as in Step 5 above, check squareness of roller by sweeping indicator across diameter on one end of roller, then sweeping the other end. Rotate tappet roller 180° and check again at roller ends by sweeping across the diameter. See Table 4-1-1 for dimensions. It is permissible and recommended to exert some downward pressure against roller when gauging to assure firm contact against roller pin.

PT Fuel Pump Group 500

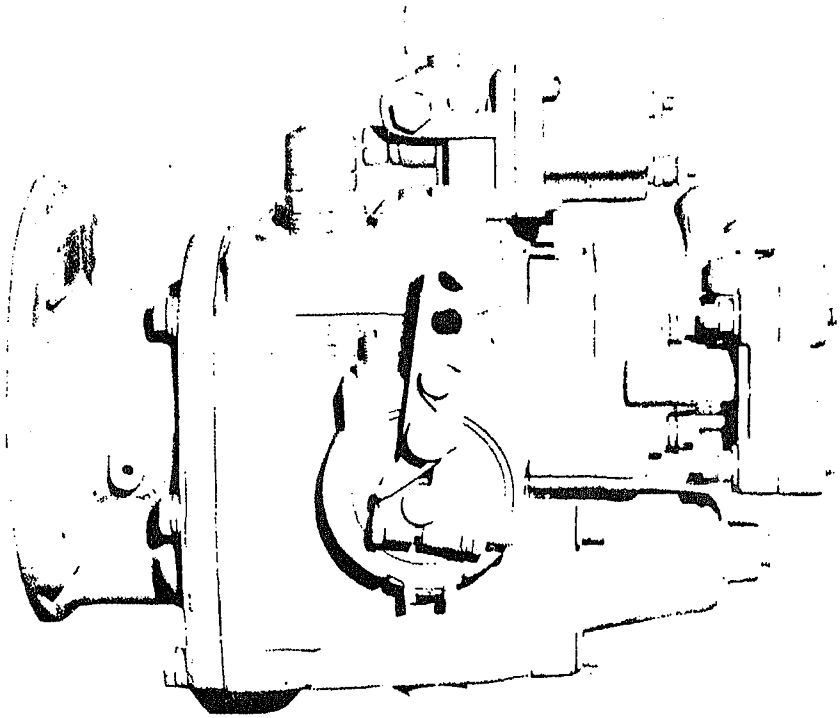


Fig. 1A. PT (type G) fuel pump — left handed gear pump

PT Fuel Pump Group

The PT fuel system is used exclusively on Diesels. The identifying letters, "PT", are an a for "pressure-time."

The designation PT (type G "Governor Controllo

Hereafter, these designations will be u scribe both the fuel system and the fuel pump

Operating Principles—Unit 501

We can better understand the PT fuel pumps if we know the basic functions of the complete fuel system.

Detailed operation of the injectors is described in Unit 6 which covers operation, cleaning and calibration of injectors.

The operation of the PT Fuel System is based on the principle that the volume of liquid flow is proportionate to the fluid pressure, the time allowed to flow and the size of passage the liquid flows through. To apply this simple principle to the PT Fuel System, it is necessary to provide:

1. A fuel pump to draw fuel from the supply tank and deliver it to individual injectors for each cylinder.
2. A means of controlling the pressure of the fuel being delivered by the fuel pump to the injectors so the individual cylinders will receive the right amount of fuel for the power required of the engine.
3. Fuel passages of the proper size and type so that the fuel will be distributed to all injectors and cylinders with equal pressure under all speed and load conditions.
4. Injectors to receive low-pressure fuel from the fuel pump and deliver it into the individual combustion chambers at the right time, in equal quantity and proper condition to burn.

Fuel Pump

The fuel pump is coupled to the compressor drive which is driven from the engine gear train. The fuel pump main shaft turns at engine crankshaft speed, and drives the gear pump, governor and tachometer shaft.

PT (type G) Fuel Pump

The PT (type G) fuel pump can be identified sence of the return line at the top of the fuel pump assembly is made up of three main units.

1. The gear pump which draws fuel from the sup forces it through the pump filter screen to the g
2. The governor which controls the flow of the fu gear pump, as well as the maximum and idle en
3. The throttle which provides a manual control to the injectors under all conditions in the oper The location of fuel pump components is indica 501-2.

Gear Pump And Pulsation Damper

The gear pump is driven by the pump main sh tains a single set of gears to pick-up and throughout the fuel system. A pulsation damp to the gear pump contains a steel diaphragm wh

the gear pump, fuel flows through the filter screen

e PT (type G) fuel pump, to the governor assembly
own in Fig. 501-2.

ently, PT (type G) gear pumps are equipped with a
l line (to the engine injector return line or to tank)
prevents excessive fuel temperatures within the fuel
. The bleed line functions primarily when the pump
le is set at idle speed but gear pump output is high,
o engine rotative speed, as occurs at down hill opera-
A special check valve and/or fitting is used in the gear
to accomplish the bleed action.

tle

the throttle provides a means for the
tor to manually control engine speed above idle as
red by varying operating conditions of speed and load.

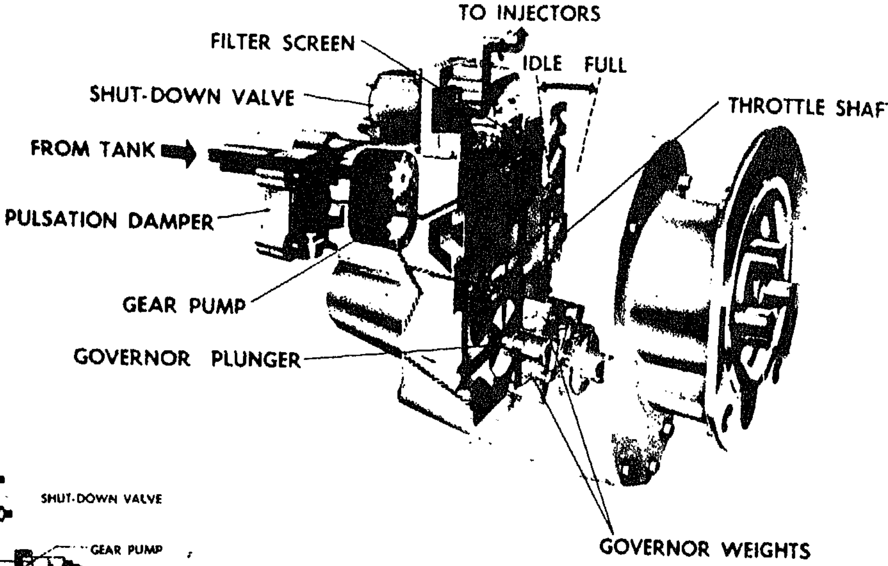
Governors

Idling and High-Speed Mechanical Governor

The mechanical governor, sometimes called "automotive governor"

is actuated by a system of springs and weights, and has two functions. First, the governor maintains sufficient fuel for idling with the throttle control in idle position; second, it cuts off fuel to the injectors above maximum rated rpm. The idle springs in the governor spring pack positions the governor plunger so the idle fuel port is opened enough to permit passage of fuel to maintain engine idle speed.

During operation between idle and maximum speeds, fuel



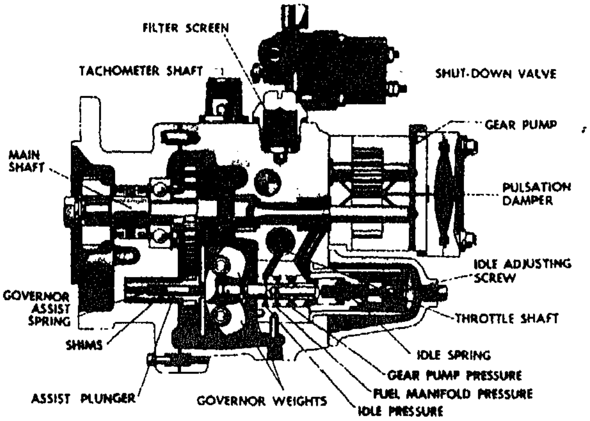


Fig. 501-2 PT (type G) fuel pump cross-section and fuel flow

FWC5-F

flows through the governor to the injectors in accord with the engine requirements as controlled by the throttle and limited by the size of the idle spring plunger counterbore on PT-(type G) fuel pumps. When the engine reaches governed speed, the governor weights move the governor plunger, and fuel passages to the injectors are shut off. At the same time another passage opens and dumps the fuel back into the main pump body. In this manner engine speed is controlled and limited by the governor regardless of throttle position. Fuel leaving the pump flows through the shut-down valve, inlet supply lines and on into the injectors.

The majority of automotive-type vehicles are equipped with what is commonly referred to as the automotive, or maximum speed governor. This includes the normal throttle shaft to which the foot throttle is attached. The throttle shaft position may be used to set engine speed between idle RPM and maximum no load engine speed so long as the load on the engine does not fluctuate.

The automotive type governor cannot be expected to ulate engine speed below full load governed speed, when trying to regulate engine speed by reducing the th tle position, a slight variation in load from the power off driven equipment will cause a widely varying en speed. For all applications in which the engine is dri power take off equipment, and at the same time the erator is not controling engine speed by maintaining stant touch with the throttle, it is recommended that N governors be used.

PT (type G) Mechanical Variable-Speed (MVS) Governors

This governor supplements the standard automotive governor to meet the requirements of machinery on which the engine must operate at a constant speed, but where extremely close regulation is not necessary.

Adjustment for different rpm can be made by means of a lever control or adjusting screw. At full-rated speed, this governor has a speed droop between full-load and no-load of approximately eight percent. A cross-section of this governor is shown in Fig. 501-5.

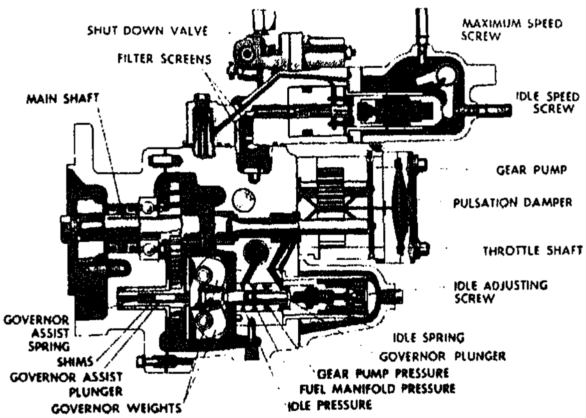
As a variable-speed governor, this unit is suited to the varying speed requirements of cranes, shovels, etc., in which the same engine is used for propelling the unit and driving a pump or other fixed-speed machine.

As a constant-speed governor, this unit provides control for pumps, nonparalleled generators and other applications where close regulation (variation between no-load and full-load speeds) is not required.

The (MVS) governor assembly mounts atop the fuel pump, and the fuel solenoid is mounted to the governor housing. See Fig. 501-5. The governor also may be remote mounted.

Fuel from the fuel pump body enters the variable speed governor housing and flows to the governor barrel and plunger. Fuel flows past plunger to the shut-down valve and on into the injector according to governor lever position, as determined by the operator.

The variable speed governor cannot produce engine speeds in excess of the automotive governor setting. The governor can produce idle speeds below the automotive pump idle speed setting, but should not be adjusted below the automotive fuel pump speed setting when operating as a combination automotive and variable speed governor.



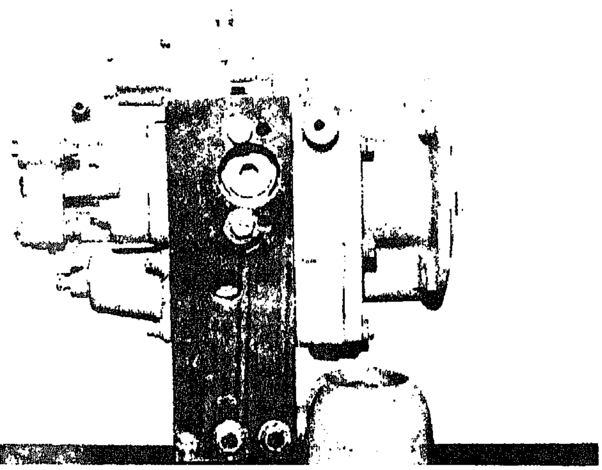
Shut Down Valve

an electric shut-down valve is used
Cummins fuel pumps.

With the electric valve, the manual control knob must
fully counter-clockwise to permit the solenoid to open
valve when the "switch key" is turned on. For emerge
operation in case of electrical failure, turn manual k
clockwise to permit fuel to flow through the valve.

Removal Of Fuel Pump Units

This unit covers disassembly of the Cummins PT (typ
and type R) fuel pumps. When a part is used only on
specific fuel pump, it is clearly indicated as such. Howe
a PT (type G) fuel pump is used as the basic unit. Insp
tion should be performed at all times during rebuild w



501-7 Fuel pump mounted to ST-546 F501

an And Mount

an outside of fuel pump thoroughly with an approved vent. Remove lockwires and seals if used.

ution: Many solvent cleaners are injurious to aluminum. ke sure your cleaner is suitable before using it on minum.

unt fuel pump on ST-546 Holding Fixture and ST-302 vel Vise. Fig. 501-7.

(type G) Fuel Pump Service Cooling Kit

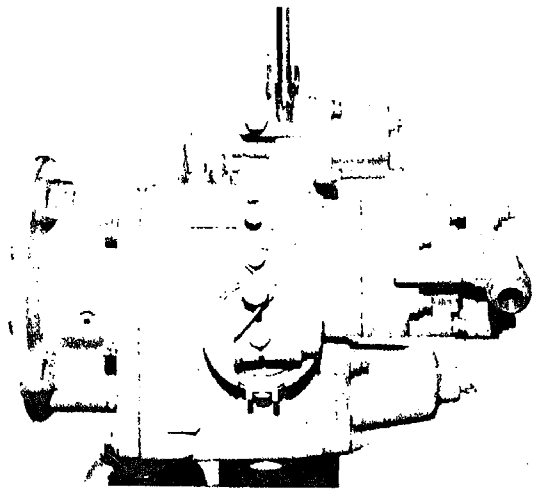
nove check valve and orifice elbow assembly from bot- or back side of fuel pump.

e: Current pumps have the check valve located at the r pump and older pumps should be changed over at any e a new gear pump is used.

an parts in clean fuel oil and dry with compressed air wn thru both ends.

t-Down Valve

nove capscrews, lockwashers and flatwashers securing



501-8 Removing shut-down valve F502

Fig. 501-9 Removing pulsation damper capscrews F503

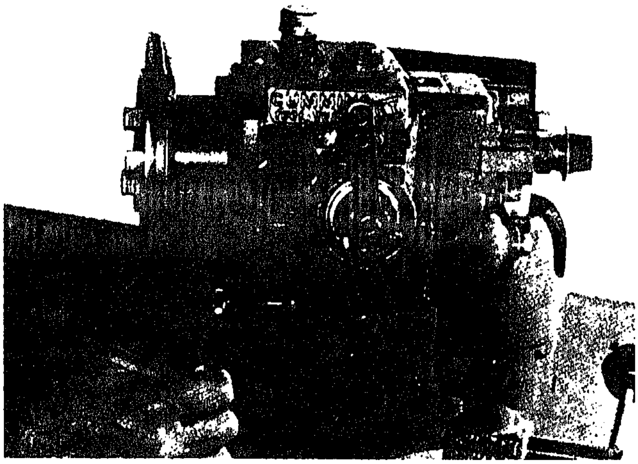


Fig. 510-10 Removing drive cover capscrews F504

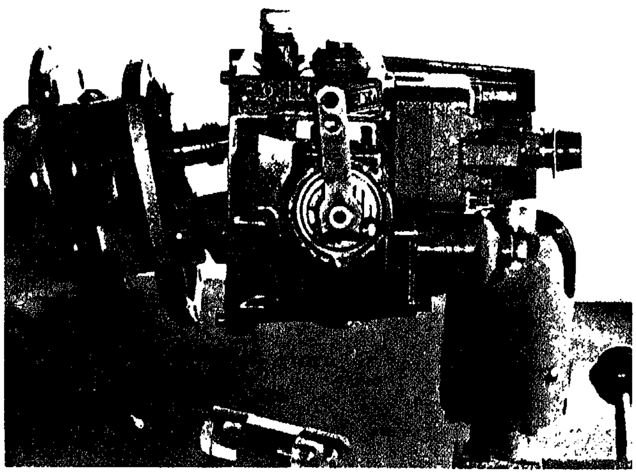


Fig. 501-11 Removing drive cover F505

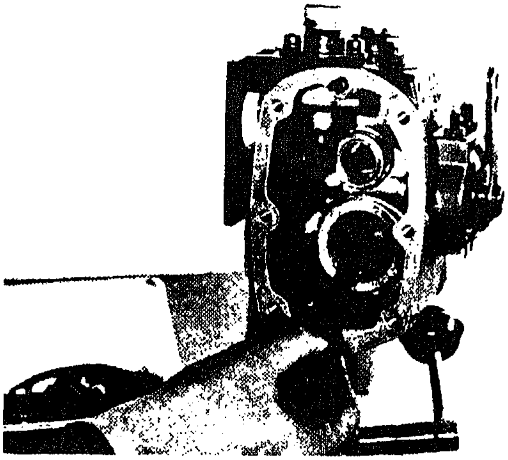


Fig. 501-12 Removing governor plunger F506

valve to top of main housing. Fig. 501-8.

2. Lift off *shut-down valve and discard "O" ring.*

Pulsation Damper

1. Remove the capscrews, lockwashers and flatwashers securing pulsation damper to gear pump. Some dampers are fitting mounted and are removed by screwing damper from fitting on gear pump. Fig. 501-9.
2. Lift off damper and discard "O" ring.

Front Drive Cover

1. Remove capscrews, lockwashers and flatwashers securing drive cover to main housing. Fig. 501-10.
2. Tap edge of cover lightly with a plastic hammer to loosen.
3. Lift cover off dowels and discard gasket. Fig. 501-11.

Caution: Never use a steel hammer on aluminum, or on a finished surface, it can cause extensive damage.

4. Remove weight assist plunger, spring and shims from weight carrier assembly.

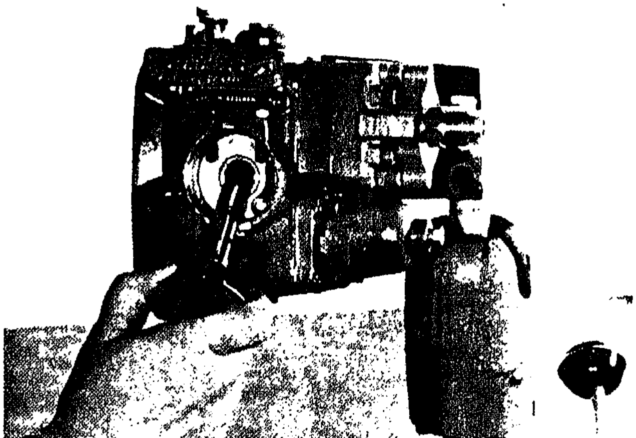


Fig. 501-13 Removing throttle assembly F507

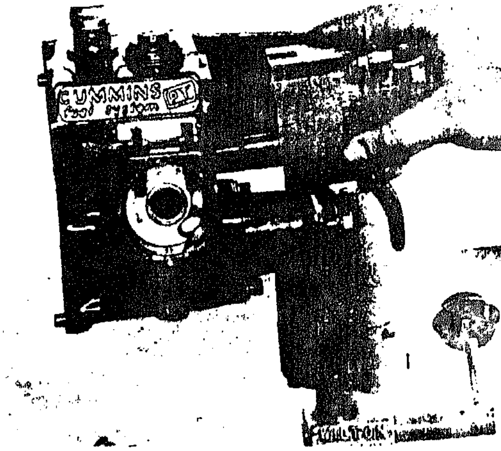


Fig. 501-14 Removing gear pump F

Governor Plunger

1. *Slide governor plunger from barrel.* Fig. 501-12.

Caution: Place plunger where it will not be damaged slight nick can cause extensive damage.

Throttle Assembly

1. Compress nameplate retaining ring and remove fr groove.
2. Pull throttle assembly from pump. Fig. 501-13. The thro shaft is a select fit in its sleeve and sizes are identified color code.

Caution: Handle throttle shaft with care.

Gear Pump

1. Remove capscrews and lockwashers securing gear pump *main housing.*
2. Tap side of gear pump with a plastic hammer to loos from dowels.
3. Lift gear pump off and discard gasket. Fig. 501-14.

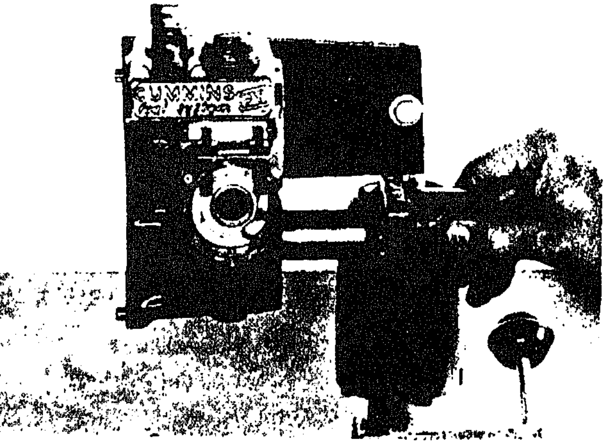
Governor Spring-Pack

The "Automotive" or idling and high speed mechar governor is standard on most engines. See Section 507 509 for other governors.

1. Remove capscrews, lockwashers and flatwashers secu governor spring-pack cover to main housing.
2. *Lift off cover and discard gasket. Fig.* 501-15.
3. Remove snap ring which holds governor spring pack sleeve with a pair of snap ring pliers.
4. Remove high-speed spring, spring retainer and shims f spring-pack housing.
5. *Remove idle-spring plunger guide, idle spring or spri* idle spring plunger, and spring rest washer. Fig. 501-16.

Filter Screen Cap

1. Loosen filter screen cover on top of main housing.
2. Lift cap, spring and filter screen assembly from m housing; discard "O" ring. The screen assembly is m



. 501-15 Removing spring pack cover F509

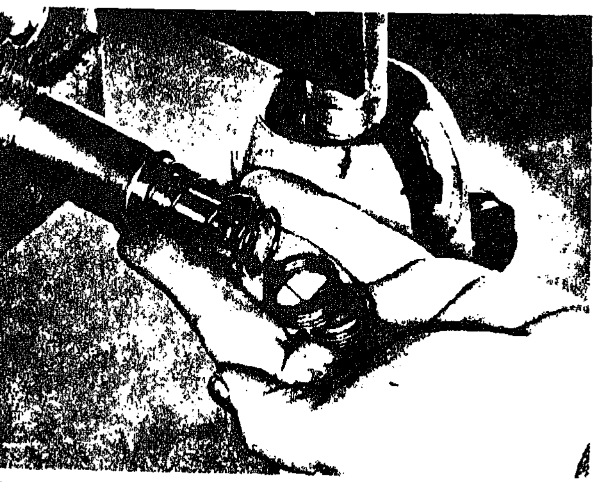
of a screen, magnet and two retainers. The bottom re-
ner has a hole in center to permit fuel flow; this retainer
soldered to the screen. Fig. 501-17.

ean magnet before reassembly; it is soldered to top re-
ner and is designed to catch particles of *iron* which are
rn or chipped from pump parts or enter with the fuel
pply.

te: MVS governors and other special applications have
uble screen arrangements. The upper screen can not be
assembled.

ssure Regulator

ssure regulators are used only on PT (type R) pumps.
e PT (type G) pump has a socket type plug at this loca-



501-16 Removing spring pack assembly F510

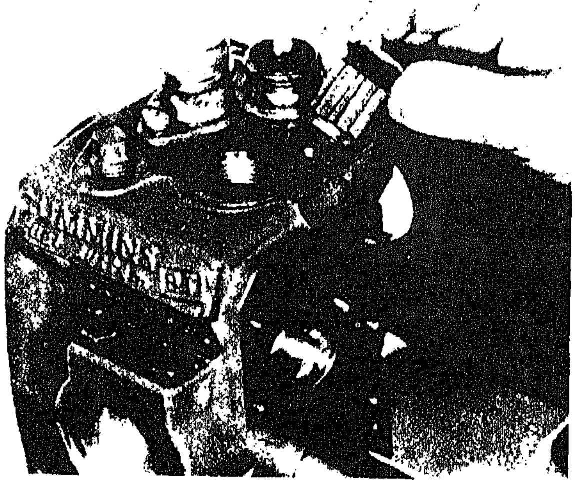


Fig. 501-17 Removing filter assembly F511

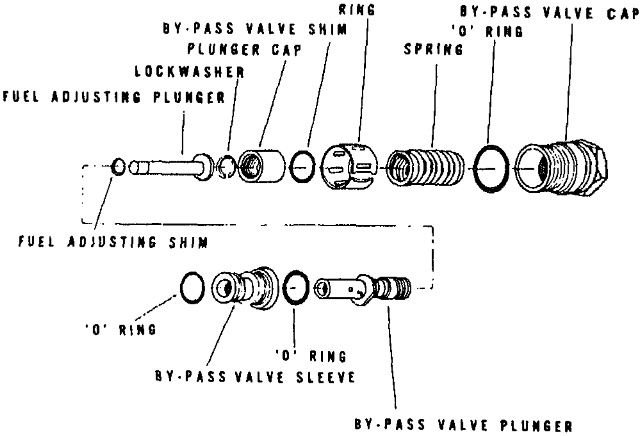


Fig. 501-18 Pressure regulator—exploded view F5184

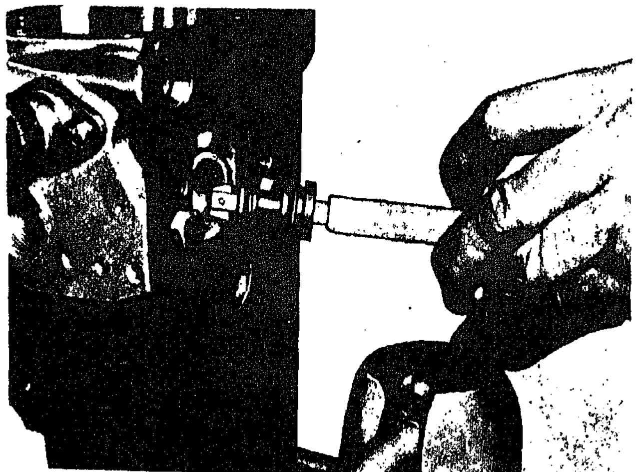


Fig. 501-19 Removing by-pass valve sleeve F512

tion, do not remove unless seal is leaking.

1. Remove pressure regulator cap from pump housing. Slip "O" ring from cap. Fig. 501-18.
2. Remove by-pass valve ring, spring shim, and by-pass valve plunger assembly. Remove fuel adjusting plunger cap with screwdriver. Lockwasher, fuel adjusting plunger, and fuel

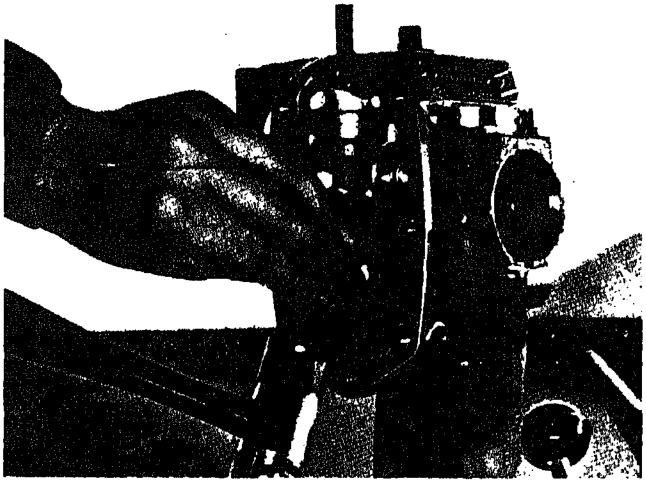


Fig. 501-20 Removing tachometer drive assembly F513

adjusting shims may then be removed from by-pass valve plunger.

3. Insert Cummins ST-586 (without sleeve) in by-pass valve sleeve. Fig. 501-19. Pull to remove sleeve. Discard "O" rings.

Tachometer Drive

1. Remove tachometer drive cover screws.
2. Lift drive cover and gasket from main housing. Discard gaskets.
3. Carefully drive tachometer drive assembly from main housing, using a brass punch and hammer. Fig. 501-20.
4. Remove seal from shaft and discard.

General

Fuel pump sub-assembly repair, cleaning, inspection and rebuild instructions are listed in the following sections.

Worn replacement limits are given to help the mechanic decide when to replace parts or to use parts that have many hours or miles of useful life.

However, parts that are worn beyond replacement limits must not be re-used.

Cleaning

A clean shop, clean tools and good cleaning practices are must be taken when cleaning aluminum alloy parts some cleaning solvents will attack and corrode alun However, cleaning time is always well spent. Mos pump failures occur because of dirt. Clean all parts l rebuild or assembly.

Inspection

Time spent on inspection is profitable. It can save dollars worth of parts and also prevent failure of tl built pump.

Too often, inspection is performed too lightly or no formed at all. Proper tools are essential to do a satisf job of inspection.

Tools

Using proper tools has many advantages. The fuel consists of several aluminum parts, which makes it but the parts may be easily damaged if the right tool used to perform the job being done.

Note: Aluminum parts must be handled carefully.

Service tools may be purchased from your Cummin tributor if you perform your own rebuild work.

An arbor press should be used for all pressing oper to control pressure and alignment. Always make sur the part is properly supported when pressing in ar part; the parts can easily be damaged beyond repair properly supported.

Pressing Lubricant

A high pressure lubricant should be used on matin faces in all pressing or driving operations. The lub prevents galling or scoring during assembly. Be sure move all burrs from mating parts before pressing tog

Capscrews And Washers

Current fuel pumps are built with 1/4" hexagon heac screws in place of the socket head screws formerly They are interchangeable.

Capscrews used in connecting a part to aluminum s have an engaging thread length two times the dia Observance of this rule will prevent stripping thread a capscrew that is too short or breaking a part from a capscrew that is too long.

Lockwashers must never be used next to aluminum. A use a flatwasher between the lockwasher and alur part.

Parts Replacements

Always determine the need, if possible, before bling the unit and then replace only parts replacing.

Instructions for complet ment are given in this to perform all operatior

PT Fuel Pump Group

Fuel Filters—Unit 502

Fuel Pump Filter Screen

Disassembly And Inspection

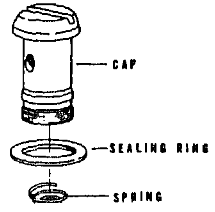
Screen assemblies used in "MVS" governor contain screen assemblies. The top screen can not be disass bled. Fig. 502-2.

a. The top screen assembly has a hole in the bottom to a fuel flow. Clean assembly in fuel oil and dry with c pressed air.

b. The lower screen assembly has holes in both ends and be disassembled. Clean screen and retainers in fuel oil dry with compressed air.

c. Inspect screens for breaks or holes in mesh or o damage.

d. Replace worn or damaged parts with new.



nstall lower screen; one with holes in each end.

nstall screen retainer and new "O" ring.

nstall upper screen; hole down.

nstall spring.

ubricate new "O" ring and place on cap.

nstall cap and torque to 25/30 ft. lbs.

'uel System Filters

ilter Change Period

Vhen rebuilding a fuel pump, new fuel filter elements hould be installed. There-after change period can best be etermined by measurement of fuel restriction. Connect T-434 Vacuum Gauge to fuel pump using special adapter urnished. Fig. 502-3. If restriction reads 8 to 8.5 inches acuum while engine is running at full speed and load, hange element or remedy other sources of restriction. Vhen restriction becomes as great as 10 or 11 inches acuum the engine will loose power.

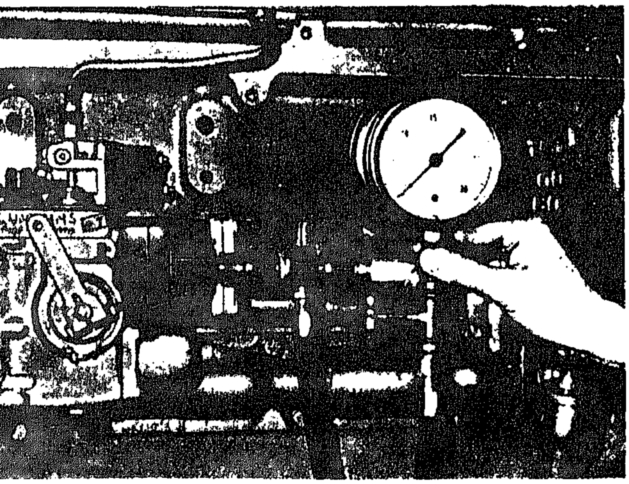
change period is not determined by checking restriction lements can be changed as follows:

:hange

the stack disc (replaceable element) after 000 gallons fuel consumption.

Vhen double elements of the standard or extended life throw-away) fuel filters are used, the capacity is approx-nately doubled.

lote: Change periods listed above is under normal work-ng conditions and with proper storage of fuel.



ig. 502-3 Checking filter restriction with ST-434

Replaceable Element Type Filter

1. Remove drain plug from bottom of filter case and drain contents; install drain plug and tighten to 5/10 ft. lbs.
2. Loosen nut at top of fuel filter. Take out dirty element clean filter case and install a new element. Fig. 502-5.
3. Install a new gasket in filter head and assemble case and element. Fill filter case with clean fuel to aid in faster pick-up of fuel pump. Tighten center bolt to 20/25 ft lbs. with torque wrench.
4. Check fittings in filter head for leaks. Fittings should be tightened to 30/40 ft lbs.

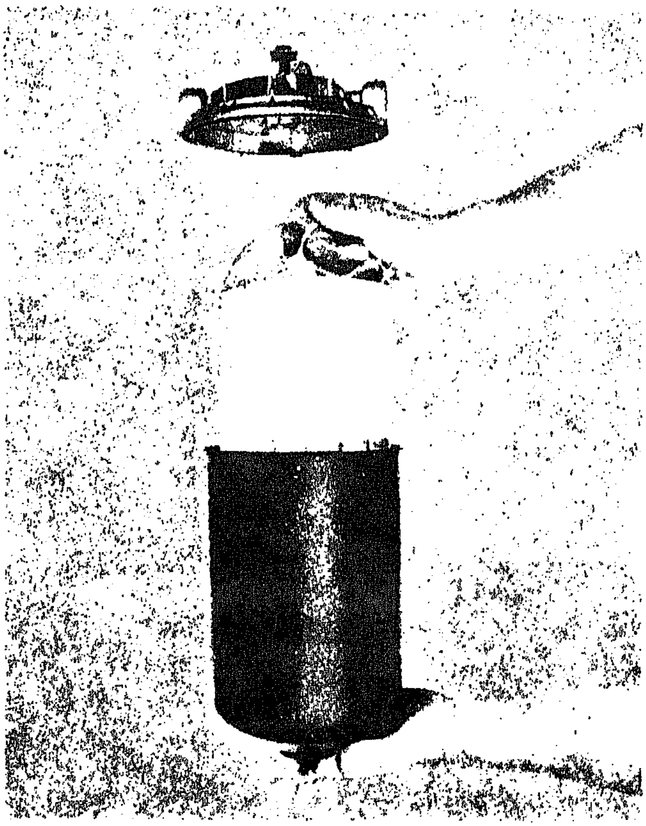


Fig. 502-5 Replaceable element fuel filter

PT Fuel Pump Group

Fuel Pump Housing—Unit 503

Main Housing

The drive shaft bushing, throttle sleeve, governor barrel and spring pack housing still remain in the fuel pump main housing.

The drive shaft bushing and governor barrel can be removed if damaged. The throttle sleeve was honed to size after assembly to the housing, and due to the close tolerances must be returned to Depot maintenance for repair or replacement.

Drive-Shaft Bushing

1. Check drive shaft bushing for sign of seizure or burrs.
2. Check drive shaft bushing I.D. with inside micrometers; if worn beyond 0.7525 inch replace bushing.
3. Remove worn bushing using a gouge chisel or half inch pipe tap. After tapping bushing, screw a half inch pipe cap on a close nipple and screw the half inch nipple into the bushing. Insert a punch through the rear of the housing and drive out the bushing.
4. Apply a thin coat of high pressure lubricant to a new front [illegible] bushing; press bushing into housing flush with [illegible] arbor press.
5. Line ream bushing to 0.7495/0.7505 with ST-490 Ream Fixture, and a well oiled 0.750 inch (3/4 inch) reamer. Fig. 503-1. Check bushing I.D.

Governor Barrel, Plunger And Spring Pack Housing

Inspection

1. Check governor barrel and plunger visually for wear.
2. If worn, replace governor plunger with a one or two class larger plunger and lap to fit with No. 80 fine grit lapping compound. Fig. 503-2. Remove all lapping compound from parts (flush thoroughly).

Note: Plunger must drop into barrel of its own weight. Proper fit can best be judged by comparison with a new assembly.

Disassembly

1. If governor barrel is worn too large for a Class 7 governor plunger on PT (type G) pumps
it will be necessary to heat housing in oven to 300°F and

Fig. 503-1 Reaming drive shaft bushing F514

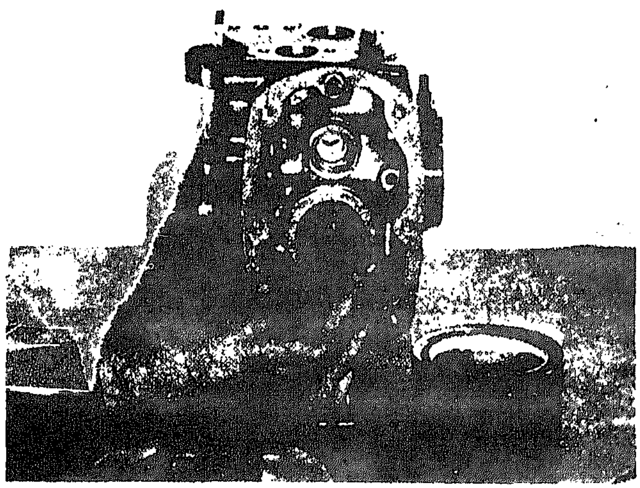
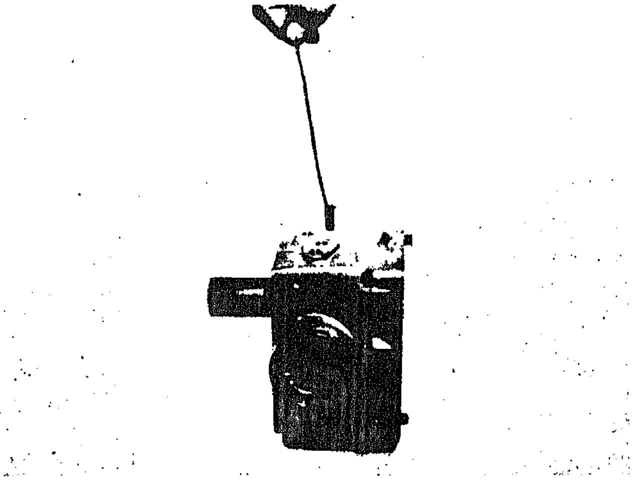


Fig. 503-2 Lapping governor plunger to barrel



ig. 503-3 Removing locking clip from bottom of fuel pump housing F5135

ress out worn governor barrel. Heat will expand the luminum housing and permit the steel barrel to be pressed ut with less chance of damaging housing bore.

Caution: Check through plug hole in bottom of PT (type G) ump for spring dowel which secures barrel in fuel pumps uilt after May 1963, before attempting to remove governor arrel. To pull spring dowel, insert wire hook into hole rovided. Fig. 503-3.

Check barrel bore in housing to determine whether stanlard (1.5020/1.5015 O.D.) barrel, .010 inch or .020 inch overize must be used. Minimum .001 inch interference fit is equired. Check bore for score marks, remove if found.

Assembly And Fitting

o locate a new governor barrel in the housing, scribe a enter line on barrel and housing, lining up the fuel pasages so fuel flow will not be restricted. Fig. 503-4 and 03-5.

Heat housing in oven to 300°F.

Cool barrel in dry ice or other method.

Coat new governor barrel with STP or other high pressure ubricant.

Drop spring pack housing in place.

Place governor barrel in housing bore with chamfered end irst and location pin hole on bottom side, lining up scribe marks, then press barrel in housing with arbor press until t bottoms against spring pack housing. This is important o align barrel retaining pin holes.

Select a new Class 2 (green color code) plunger and atempt to fit it in barrel, if plunger enters, try a Class 3 yellow). Keep trying larger sizes until one will not enter arrel, then select one two sizes smaller for use. Plunger must drop into bore of its own weight. Lapping may be required to obtain desired plunger fit. Use caution and clean

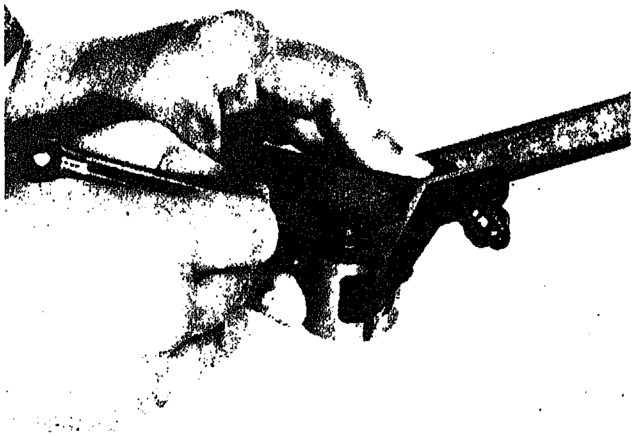


Fig. 503-4 Scribe center line on governor barrel F516

thoroughly if lapped. See Tables 503-1 or 503-2 for class sizes and color codes. The 168630 plungers can be differentiated from the 169660 plungers by the presence of a 10 degree chamfer located next to the dump groove on the plunger. (Width of chamber on 168630 series plungers is .018 in. smaller than chamfer on 169660 plungers.)

8. Brush plunger lightly with crocus cloth to remove any lubrite crystals.
9. Check plunger fit with a new fuel pump assembly as a fit comparison.
10. If lapping is necessary, see Step 7 preceeding and Step 2 under "Inspection"
11. Install spring dowel into bottom of barrel with ST-853 driver with slot of pin to front of housing. Fig. 503-8.

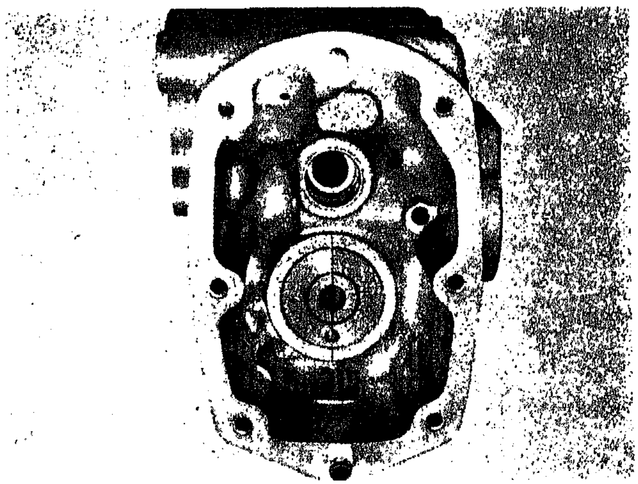


Fig. 503-5 Scribe center line on fuel pump housing F5136

Table 503-1: Current PT (type G) Governor Plungers

Code	Red	Blue	Green	Yellow	Brown	Black	Gray	Purple	Usage
Size	0	1	2	3	4	5	6	7	
Part No.	169660	169661	169662	169663	169664	169665	169666	169667	Standard

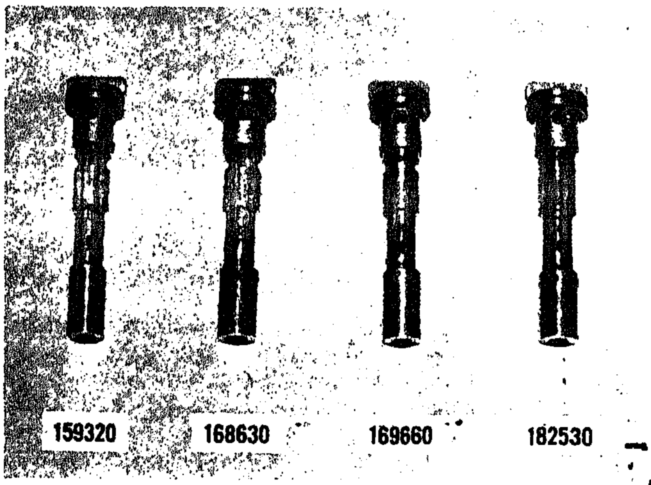


Fig. 503-6 Current PT (type G) governor plungers F5137

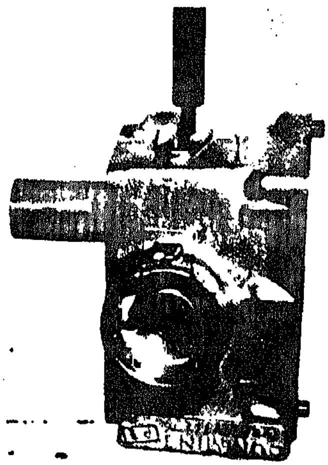


Fig. 503-8 Installing spring dowel in bottom of fuel pump housing F

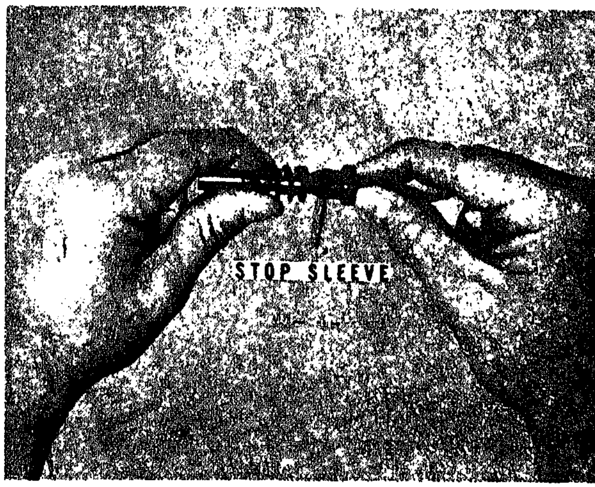


Fig. 503-9 Removing torque spring F

rnor Plunger

essary, remove torque spring (torque spring used on pe G) governor plungers only) by twisting spring off ler. Do not use a straight pull which will stretch spring d its elastic limit so it has to be replaced. Fig. 503-9.

ernor plunger O.D. is worn, replace as an assembly. Governor Barrel and Plunger."

y thrust washer is worn, drive retainer pin from r and pull governor plunger driver from plunger. Fig.

The chamfer on small diameter of thrust washer is ed as a relief for fillets of plunger driver.

necessary to remove stop sleeve, press stop sleeve aft.

bly

sleeve was removed, press stop sleeve on plunger otched end going on plunger first (notches toward nor barrel). Fig. 503-9.

ble plunger driver through thrust washer and drive lunger. Driver must have interference fit in plunger.

retainer pin through the plunger and plunger driver.

The chamfered side of thrust washer must be in- l next to driver. There must be at least .002 to .005 learance between washer face and driver so washer loat". Fig. 503-11.

n: The plunger has a lubrite finish. Protect it by the plunger on a copper jawed vise or V-block to nt damage to the finish when installing pin.

torque spring and shims as required, put the small f the spring on the shoulder end of the plunger with a ng motion to avoid distorting the spring.

Note: The torque spring determines point of maximum torque in the engine, therefore, it is important to avoid changing spring characteristics by careless handling or assembly.

5. If torque spring is replaced with new one, select from specification sheets pertinent to the fuel pump being rebuilt, see fuel pump calibration data in Unit 511

   and Table 503-3 following.

6. One type of plunger failure is caused by excessive heat from contact of the stop collar and sleeve during long periods of overspeeding. Plunger stop collars machined from glass filled teflon eliminate this type of failure.

   Because of the large outside diameter of the teflon stop collar it is impossible to use a torque control spring if it is required, therefore, the teflon stop collar is to be used only in PTG fuel pumps that do not require a torque control spring.

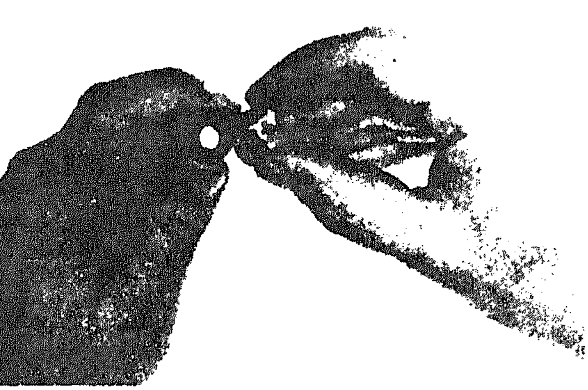
Tachometer Drive

Disassembly

1. Remove oil seal from tachometer drive shaft.
2. Press tachometer drive shaft from drive gear and bushing if the gear is badly worn or shaft and bushing are galling or scoring check shaft O.D., it should be 0.3100/0.3105 and bushing I.D. should be 0.312/0.313. Replace if necessary.

Rebuild

1. Current fuel pumps now have an improved tachometer drive seal lubrication arrangement. The tachometer drive bushing has been revised to include fuel passage grooves in the top, bottom, and bore. All current fuel pump housings now have an oil passage hole drilled from the tachometer drive bushing ledge into the main housing. A new



3-10 Removing governor plunger driver F536

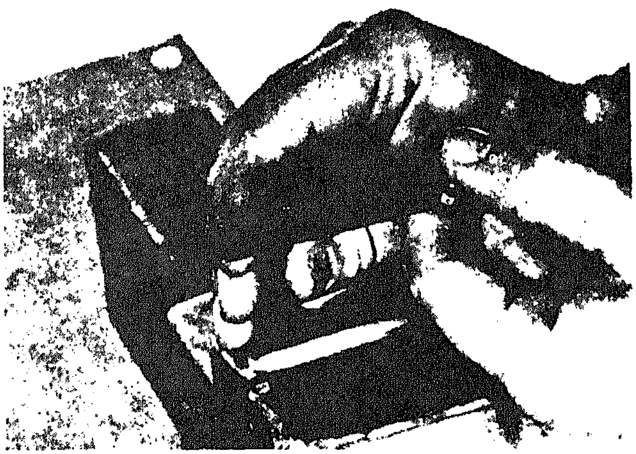


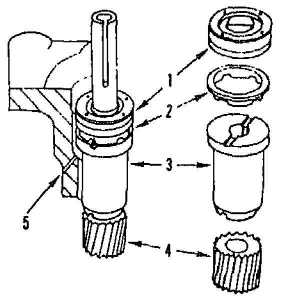
Fig. 503-11 Checking clearance between washer and driver F536

Table 503-3: Torque Springs

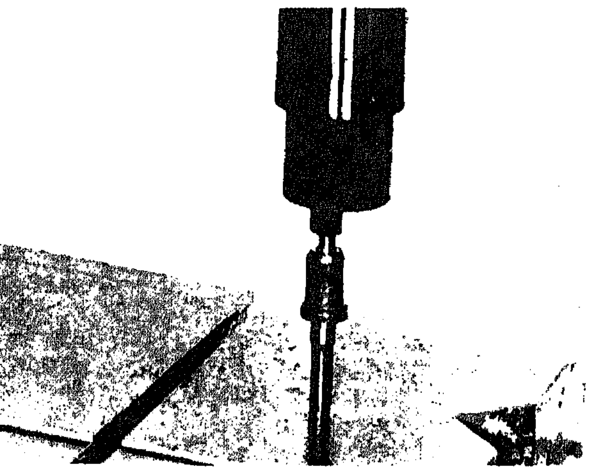
Part Number	Color Code	Wire Diameter	Number Coils	Pounds Load	@	Inches Length	Free Length
138768	Red	.044	6.47	3.00/3.20	@	.340	.640
138769	Blue	.044	5.72	3.60/3.84	@	.340	.640
138780	Brown	.044	5.19	4.20/4.48	@	.340	.640
138781	Yellow	.047	5.57	4.80/5.12	@	.340	.640
138782	Red/Blue	.047	5.17	5.40/5.76	@	.340	.640
138783	Red/Brown	.051	5.87	6.00/6.40	@	.340	.640
138784	Red/Yellow	.051	5.52	6.60/7.04	@	.340	.640
139584	Blue/Brown	.051	5.22	7.20/7.68	@	.340	.640
139585	Blue/Yellow	.051	4.75	7.80/8.32	@	.340	.640
139586	Brown/Yellow	.054	5.41	8.40/8.96	@	.340	.640
138785	Red	.044	6.47	2.50/2.70	@	.340	.590
138786	Blue	.044	5.72	3.00/3.24	@	.340	.590
138787	Brown	.044	5.19	3.50/3.78	@	.340	.590
138788	Yellow	.047	5.57	4.00/4.32	@	.340	.590
138789	Red/Blue	.047	5.17	4.50/4.86	@	.340	.590
138790	Red/Brown	.051	5.87	5.00/5.40	@	.340	.590
138791	Red/Yellow	.051	5.52	5.50/5.94	@	.340	.590
138792	Blue/Brown	.051	5.22	6.00/6.48	@	.340	.590
139587	Blue/Yellow	.051	4.75	6.50/7.02	@	.340	.590
139588	Brown/Yellow	.054	5.41	7.00/7.56	@	.340	.590
138793	Red	.044	6.47	2.00/2.20	@	.340	.540
138794	Blue	.044	5.72	2.40/2.64	@	.340	.540
138795	Brown	.044	5.19	2.80/3.08	@	.340	.540
138796	Yellow	.047	5.57	3.20/3.52	@	.340	.540
138797	Red/Blue	.047	5.17	3.60/3.96	@	.340	.540
138798	Red/Brown	.051	5.87	4.00/4.40	@	.340	.540
138799	Red/Yellow	.051	5.52	4.40/4.84	@	.340	.540
138800	Blue/Brown	.051	5.22	4.80/5.28	@	.340	.540
138801	Blue/Yellow	.051	4.75	5.20/5.72	@	.340	.540
138802	Brown/Yellow	.054	5.41	5.60/6.16	@	.340	.540
138803	Red	.044	6.47	1.50/1.70	@	.340	.490
138804	Blue	.044	5.72	1.80/2.04	@	.340	.490
138805	Brown	.044	5.19	2.10/2.38	@	.340	.490
138993	Yellow	.047	5.57	2.40/2.72	@	.340	.490
138994	Red/Blue	.047	5.17	2.70/3.06	@	.340	.490
138995	Red/Brown	.051	5.87	3.00/3.40	@	.340	.490
138996	Red/Yellow	.051	5.52	3.30/3.74	@	.340	.490
138997	Blue/Brown	.051	5.22	3.60/4.08	@	.340	.490
138998	Blue/Yellow	.051	4.75	3.90/4.42	@	.340	.490
138999	Brown/Yellow	.054	5.41	4.20/4.76	@	.340	.490
142698	White/Brown	.035	6.73	1.16/1.24	@	.350	.640
142697	White/Yellow	.041	7.72	1.74/1.86	@	.350	.640
142696	White/Blue	.041	6.29	2.32/2.48	@	.350	.640
142701	White/Brown	.035	6.73	0.96/1.04	@	.350	.590
142700	White/Yellow	.041	7.72	1.44/1.56	@	.350	.590
142699	White/Blue	.041	6.29	1.92/2.08	@	.350	.590
142704	White/Brown	.035	6.73	0.76/0.84	@	.350	.540
142703	White/Yellow	.041	7.72	1.14/1.26	@	.350	.540
142702	White/Blue	.041	6.29	1.52/1.68	@	.350	.540
142707	White/Brown	.035	6.73	0.56/0.64	@	.350	.490
142706	White/Yellow	.041	7.72	0.84/0.96	@	.350	.490
142705	White/Blue	.041	6.29	1.12/1.28	@	.350	.490
142843	White/Blue	.041	6.29	3.92/4.08	@	.350	.840
142844	Red	.044	6.47	4.90/5.10	@	.350	.840
142845	Blue	.047	6.76	5.88/6.12	@	.350	.840
142846	Brown	.047	6.08	6.86/7.14	@	.350	.840

'able 503-3: Torque Spring (Cont.)

'art lumber	Color Code	Wire Diameter	Number Coils	Pounds Load @ Inches Length	Free Length
42850	White/Blue	.041	6.29	3.52/3.68 @ .350	.790/.810
42851	Red	.044	6.47	4.40/4.60 @ .350	.790/.810
42852	Blue	.047	6.76	5.28/5.52 @ .350	.790/.810
42853	Brown	.047	6.08	6.16/6.44 @ .350	.790/.810
42854	Yellow	.047	5.57	7.04/7.36 @ .350	.790/.810
42855	Red/Blue	.051	6.30	7.92/8.28 @ .350	.790/.810
42857	White/Blue	.041	6.29	3.12/3.28 @ .350	.740/.760
42858	Red	.044	6.47	3.90/4.10 @ .350	.740/.760
42859	Blue	.047	6.76	4.68/4.92 @ .350	.740/.760
42860	Brown	.047	6.08	5.46/5.74 @ .350	.740/.760
42861	Yellow	.047	5.57	6.24/6.56 @ .350	.740/.760
42862	Red/Blue	.051	6.30	7.02/7.38 @ .350	.740/.760
42863	Red/Brown	.051	5.87	7.80/8.20 @ .350	.740/.760
42864	White/Blue	.041	6.29	2.72/2.88 @ .350	.690/.710
42865	Red	.044	5.47	3.40/3.60 @ .350	.690/.710
42866	Blue	.047	6.76	4.08/4.32 @ .350	.690/.710
42867	Brown	.047	6.08	4.76/5.04 @ .350	.690/.710
42868	Yellow	.047	5.57	5.44/5.76 @ .350	.690/.710
42869	Red/Blue	.051	6.30	6.12/6.48 @ .350	.690/.710
42870	Red/Brown	.051	5.87	6.80/7.20 @ .350	.690/.710



503-12. Tachometer drive parts F5214



g. 503-13. Pressing tachometer gear on shaft F537

tachometer seal spacer has been added between the drive bushing and the seal to provide fuel passage clearance. This increased lubrication arrangement has greatly improved tachometer drive seal service life.

2. These improvements can be utilized as a field fix when tachometer drive leakage is encountered by drilling a 7/64" oil passage hole in the fuel pump housing, or replacing it with a current drilled housing, and by using a new spacer and revised bushing. Fig. 503-12.

3. Drill oil passage as shown and remove all burrs with a burr knife. Use an old or used bushing as a locator. Remove the bushing from the housing before assembling drive.

Assembly

1. Place bronze bushing on tachometer shaft with chamfered end of bushing toward gear end. Press gear onto shaft until flush with end of shaft. Fig. 503-13. Check to see that shaft turns freely in bushing.

Note: *Check gear to make sure it matches with tachometer drive gear.*

2. Install the drive assembly in the fuel pump housing, pushing down until it bottoms.

3. Place the new 189638 spacer on top of the drive bushing with the *slotted edge down* against the bushing.

4. Install a new drive seal and press it down until it bottoms on the spacer. Fig. 503-12.

Caution: Do not overpress. The spacer can be flattened, eliminating its effectiveness.

PT Fuel Pump Group

The gear pump draws fuel from the tank through and supplies the fuel to the fuel pump. Fuel at a pressure is then routed to the injectors.

Gear Pump and Pulsation Damper—Unit 504

Gear Pump

PT (type G) fuel pumps currently have gear pumps with hollow idle shafts and the gear pump cover is drilled for cooling as described under "Gear Pump" Page 5-1-1.

Note: Special C.I.T.E. fuel gear pumps will have the BM or AR number stamped on the side of the gear pump.

Caution: Engines with integral cooling gear pumps (Fig. 504-2) must not be run with the fuel bleed hole plugged.

Disassembly

1. Remove capscrews securing gear cover to gear body.
2. Install two long capscrews in cover and drive against capscrew heads to remove gear cover from dowels in gear body. Discard gasket.
3. Lift drive and driven gears and shafts from gear pump body.
4. Pull any damaged needle bearings, when used, with ST-544 Puller. Fig. 504-1.

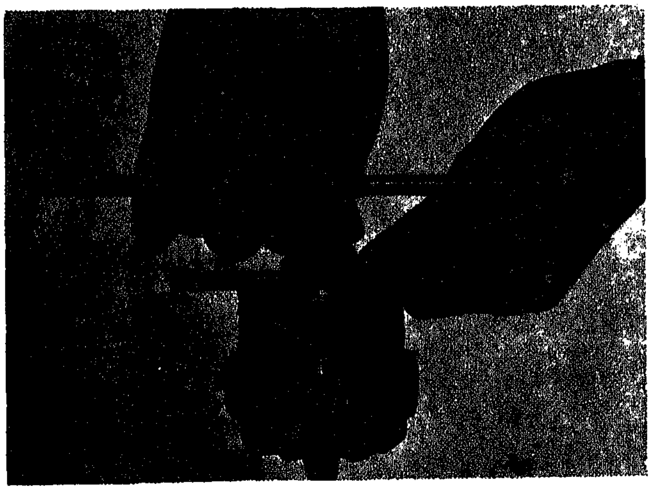


Fig. 504-1 Pulling needle bearing F521

Cleaning And Inspection

1. Check pump shafts for wear or scoring; discard aged. Replace shaft if worn smaller than 0.4998/0.50 diameter.
2. Check gear width. See Table 504-1. If gears are sc worn badly, the gears must be replaced. Fig. 504-
3. Check gear body and cover for scoring or wear, parts as needed. Check gear pocket depth. See 504-1, Fig. 504-4.
4. Shaft bore in cover and body should be 0.5013/0.50 I.D. in $\frac{7}{16}$" and $\frac{3}{4}$", and 0.5015/0.5018 inch I.D. in $1\frac{1}{4}$" in current cast iron bearing gear pumps. If ge removed from shaft press gears on shaft 0.680/0.6 from body end of shaft. Oil shaft before assembly gears on shaft, chamfered side last. The .005/.010 break on the teeth is on the same side of the gear 15° chamfer. This break must be toward the gear po the gear housing.

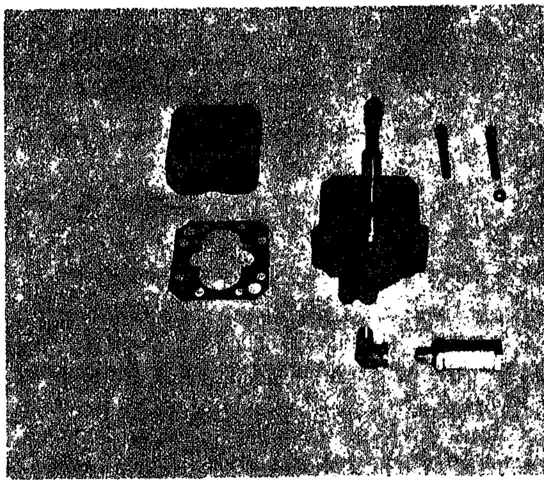
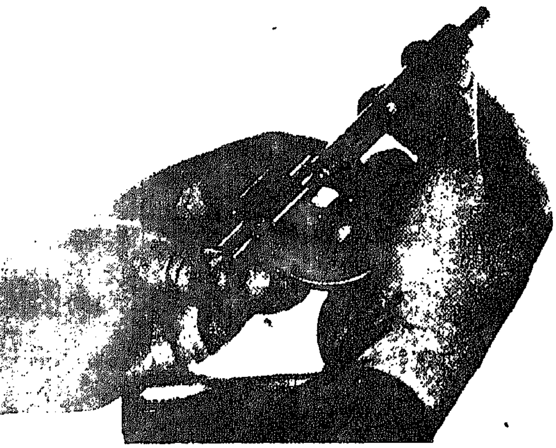


Fig. 504-2 Gear pump with integral cooling



. 504-3 Checking gear width F522

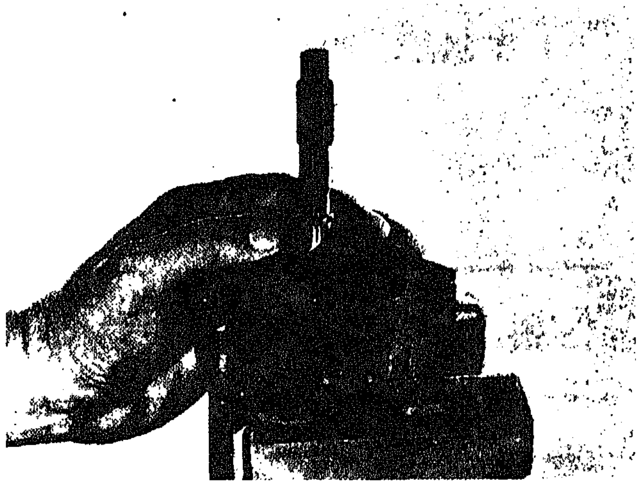


Fig. 504-4 Check gear pocket depth F523

ble 504-1: Gear Width And Pocket Depth — Inch

e mp	Gear Width	Gear Pocket Depth
″	0.4360/0.4363	0.4353/0.4356
′	0.7483/0.7486	0.7478/0.7483
	0.9980/0.9983	0.9980/0.9983
″	1.2479/1.2486	1.2482/1.2485

eck lubrication holes in cover and body; they must be ean.

ean cooling kit components, if used, and dry with compressed air.

te: If shaft bore is scored 1/3 of circumference or more cover or body, scrap part. If scored less than 1/3 clean and reuse part in current bearingless gear pump.

sembly

ess in new needle bearings, if used, with ST-545 Mandrel obtain proper location. Slide needle bearing on mandrel d press bearing into housing until mandrel hits stop.

bricate and slide shafts and gears into cover. Make sure rts are clean.

sition new gasket and install body to cover. Align locat- notches together. Fig. 504-5.

te: Location of notches determines pump rotation.

cure cover and body with dowels, capscrews and lockshers. Tighten capscrews to 13/17 foot pounds. Fig. 504- Check to see that pump turns freely with finger pressure.

te: Total gear backlash must be 0.001/0.004 inch. The ve shaft must protrude 2.370/2.412 inch from the body. d clearance should not exceed 0.0015 inch nor be less an 0.0009 inch.

Caution: If pump binds or has excessive play, check for error in assembly which must be corrected to prevent early pump failure.

5. If cooling feature is used, install elbow and/or check valve.
6. See Unit 511 for gear pump suction test as applied during pump calibration adjustments.

Pulsation Damper

Disassembly

1. Remove mounting capscrews, flatwashers and lockwashers, and separate the housing from the cover.
2. Remove the spring steel diaphragm, nylon washer and "O" rings. Discard "O" rings and nylon washer.

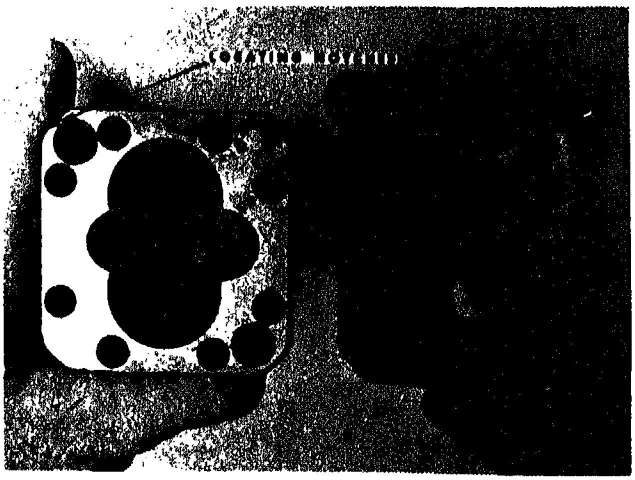


Fig. 504-5 Locating notches F524

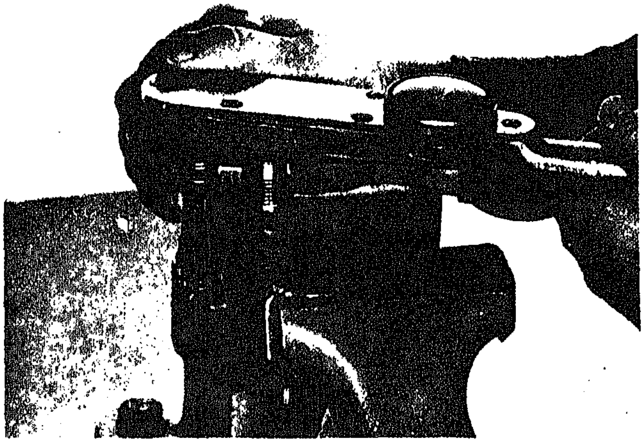


Fig. 504-6 Torquing gear pump capscrews F525

Cleaning And Inspection

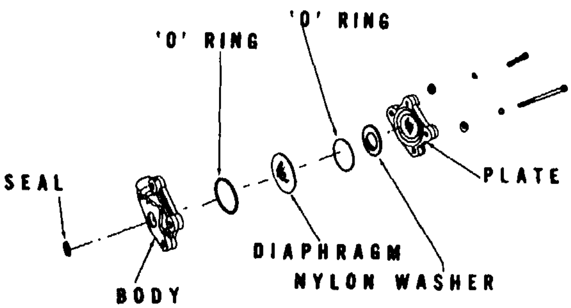
1. Clean the housing, cover and diaphragm in solvent, which is not harmful to aluminum.

   Note: Diaphragm must be kept clean prior to assembly.

2. Check for corrosion, excessive wear or cracks in cover or diaphragm. Fig. 504-7.

Assembly

1. Install new "O" rings in grooves and new nylon washer.
2. Coat the diaphragm with a good grade of 10 W or 20 W oil and lay in cover.
3. Assemble cover to housing; secure with flatwashers, lock-washers and capscrews. Torque capscrews to 8 ft. lb.



PT Fuel Pump Group

The shutdown valve controls the flow of fuel from the pump to the injectors. The electric valve is equipped with a knob which will open the valve in case of electrical power failure, keep in counterclockwise position to operate electrically.

Shut-down Valves—Unit 505

Electric Shut-Down Valve

The electric shut-down valve is held open while current is flowing through the electric coil, or solenoid. When current is not flowing valve will shut unless the shut-down valve is locked open manually.

Disassembly

1. Remove screws and lockwashers securing coil housing to valve housing. Fig. 505-1.
2. Remove coil housing, fuel shield and "O" ring. Discard "O" ring.
3. Remove spring washer and plate-type valve.
4. If necessary, remove manual override knob, and unscrew override shaft from coil end. Discard shaft "O" ring. See Fig. 505-2.

Cleaning And Inspection

1. Clean all parts except the coil assembly in mineral spirits.

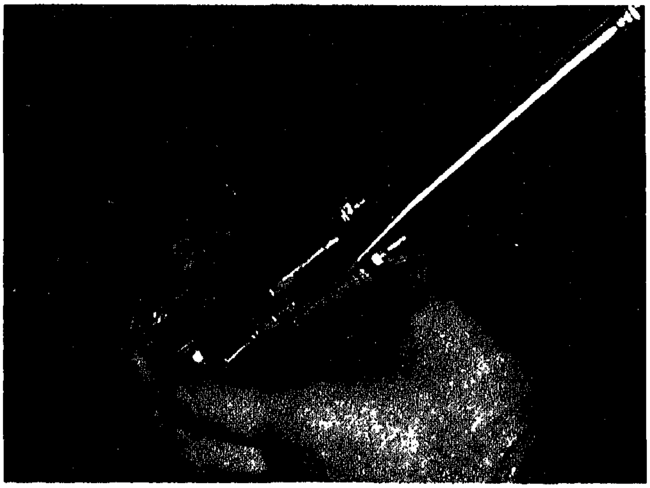


Fig. 505-1 Removing screw from shutdown valve F527

Note: Do not wet the coil with solvent; instead, wipe clean with a lint free cloth.

2. Visually check valve and valve seat for wear, bonding fa ure or corrosion. Replace if necessary. Valve seat shou have a minimum seat 0.015 inch wide. Fig. 505-3.
3. Check coil assembly with an Ohm meter, replace if belo values given in Table 505-1.

Caution: Be sure that starting switch is in off position wh checking coil.

4. The following tabulation lists the solenoid valv coil assemblies and coil resistances.

Assembly

1. If removed, install a new "O" ring on override shaft ar coat with lubricant. Fig. 505-4.

Table 505-1: Coil Resistances

	Coil Part No.		Coil Resistanc (Ohms)
	134072	12 V.D.C. Single Terminal	7.5 ± 0.5
	134073	6 V.D.C. Single Terminal	1.87 ± 0.1
*	134074	24 V.D.C. Single Terminal	30 ± 2

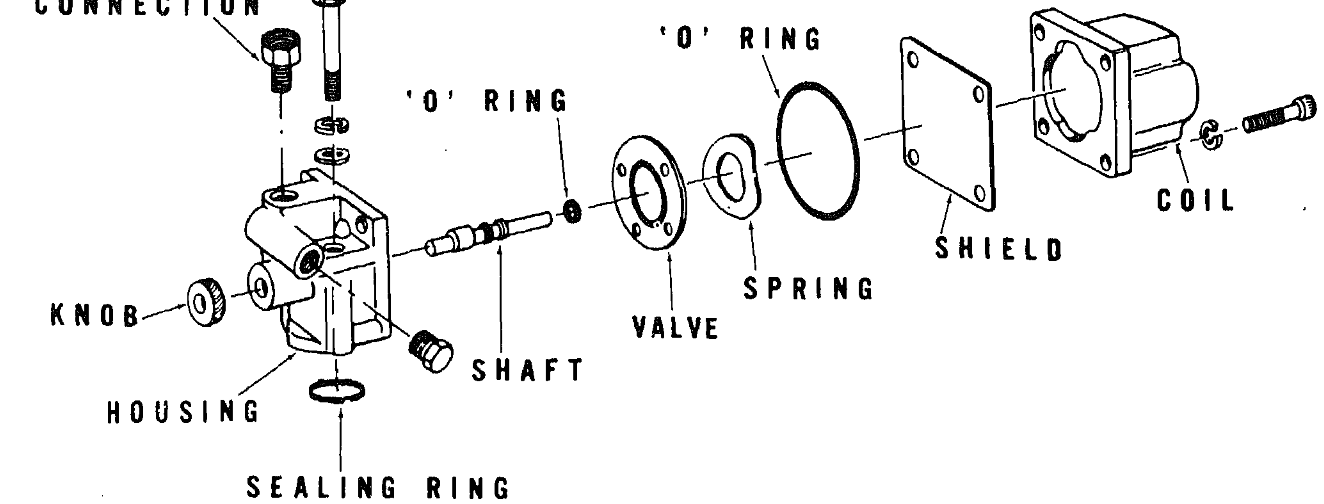


Fig. 505-2 Electric shut-down valve--exploded view F5143

Screw shaft into housing until it reaches bottom of its bore. Use depth micrometer set at 0.118 inch and check distance from face of value housing to tip of shaft. If necessary screw shaft out until it is 0.118 inch below housing face. Press on knob until it contacts valve housing, thus it will act as a stop. Fig. 505-5.

Seat valve into valve housing.

Apply lubricant to housing "O" ring and seat in groove.

Drop spring washer on valve with concave side up and piloted around valve bore. Fig. 505-6.

6. Place fuel shield on coil housing and secure to valve housing assembly with screws and lockwashers. Tighten screws to 15/20 inch-pound torque.
7. Energize valve and pump fluid through valve at 300 psi. De-energize valve and valve should withstand the 300 psi load with no leakage through valve.
8. Should leakage exist, check the main body for nicks or depressions where body and plate come in contact. Check the rubber seal in the plate for swelling or other defects.

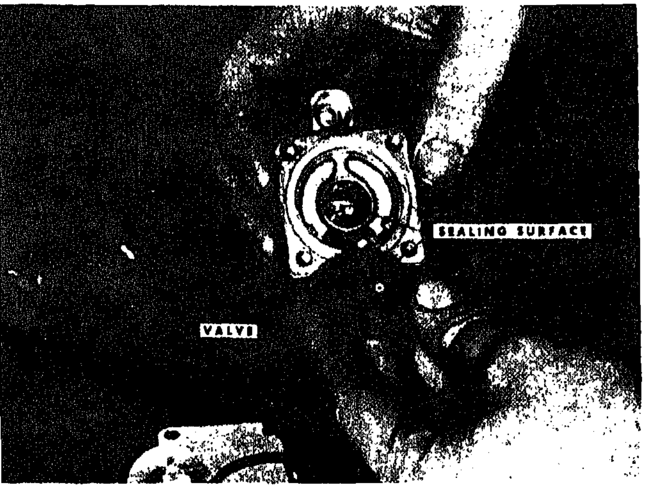


Fig. 505-3 Inspecting "plate type" valve F528

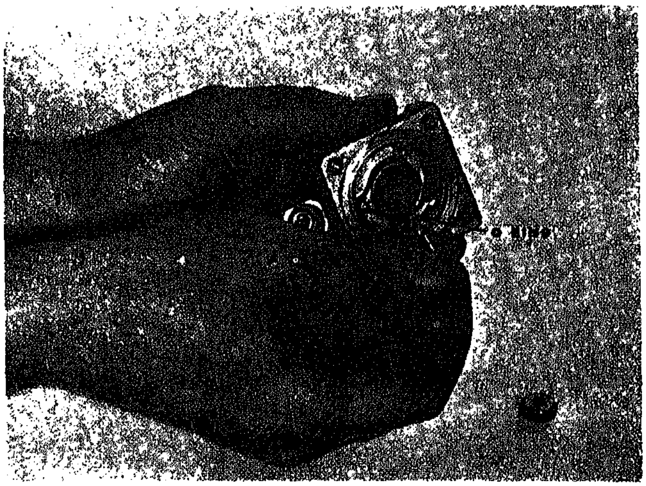


Fig. 505-4 Installing override shaft F529

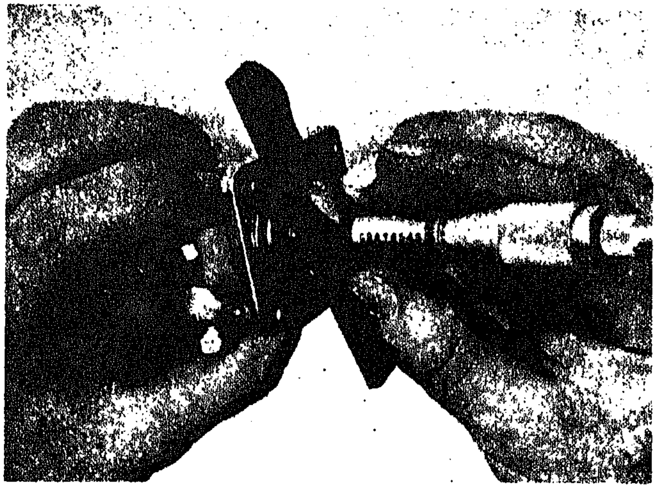


Fig. 505-5 Checking shaft tip depth F530

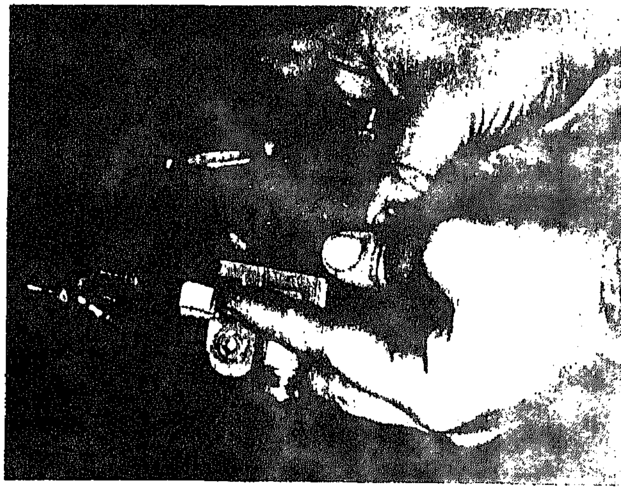


Fig. 505-6 Assembling shut-down valve F5

Front cover assemblies consist of the cover, main shaft bearing, and the governor weight carrier assembly. cover may be flange mounted to the compressor or pump drive, or the pump bracket mounted to the engi

Front Cover Assembly—Unit 506

Front Or Drive Cover

Disassembly And Inspection

1. Check governor weight carrier shaft in its bushing before removal.
2. Excessive wear can be felt by moving shaft from side to side in the bushing.
3. Observe excessive lash between weight shaft gear and drive gear.

   Note: Remove weight assist plunger if not previously removed.

4. To remove governor weight carrier assembly from drive cover, heat housing in hot water and use ST-709 Puller to pull weight shaft assembly and bushing from front cover. Fig. 506-1. The bushing is locked on shaft with a snap ring and will usually come out of cover with weight shaft assembly; however, if snap ring pulls off shaft leaving bushing in front cover, use an internal engaging puller of ST-709 to pull bushing.
5. Remove fuel pump drive coupling retainer capscrew and washers.
6. Remove large snap ring from pump end of drive shaft between drive cover and drive gear. Fig. 506-2.
7. Install a longer capscrew in place of drive coupling re er capscrew; press on capscrew to press drive gear as bly from front cover. Fig. 506-3.
8. Press drive shaft oil seals from drive cover.
9. Governor assembly can be disassembled to change weights and bushing. The governor carrier and shaft only be replaced as an assembly. If shaft is 0.388/0.392 O.D. or smaller and requires replacement, we recomm use of 0.515/0.519 inch O.D. shaft and carrier assembly new bushing as replacement parts. Fig. 506-4.

Caution: Governor weights can only be replaced in pa maintain balance.

Governor Weight Carrier

1. If governor gear, shaft, weights or weight carrier are aged, press gear from shaft. Fig. 506-5.

a. If weights or pins are worn, remove and replace weights in pairs and new pins. Gauge pin and weight wear by comparing with new assembly. Install new th washers on both sides of weights when positioned in rier. Peen the ends of pins with ST-425.

b. Make sure pins are peened securely so shafts do not on pins. Teeth on pinned shaft must be firmly imbed walls. Washers must spin freely.

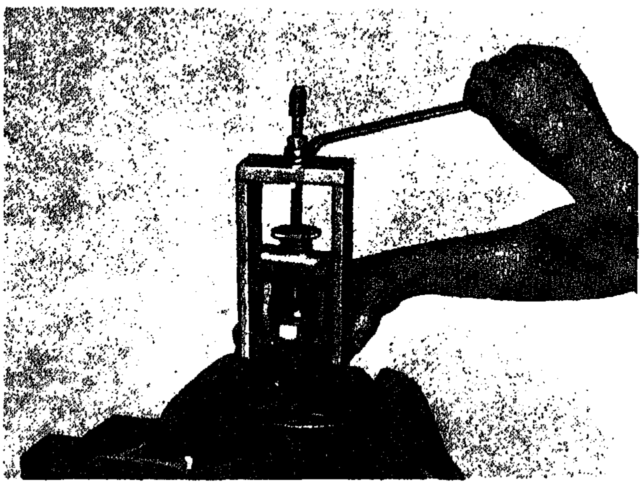


Fig. 506-1 Using ST-709 to pull weight shaft assembly F538

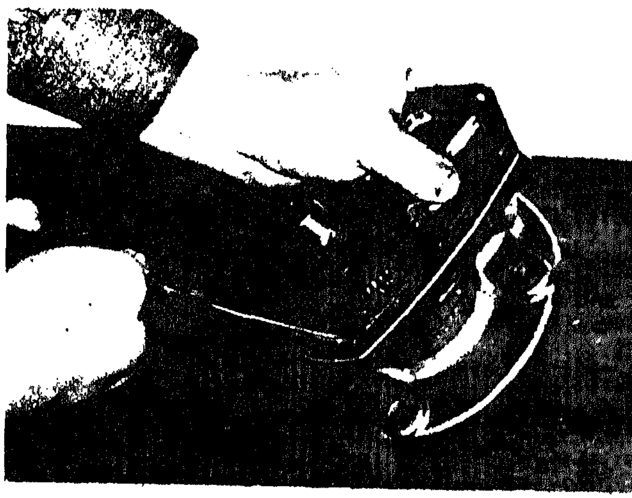


Fig. 506-2 Removing snap ring from groove

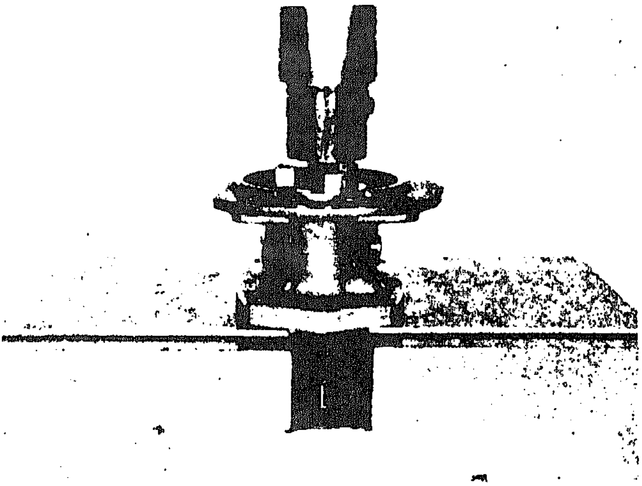


Fig. 506-3 Press drive gear assembly from front cover F5144

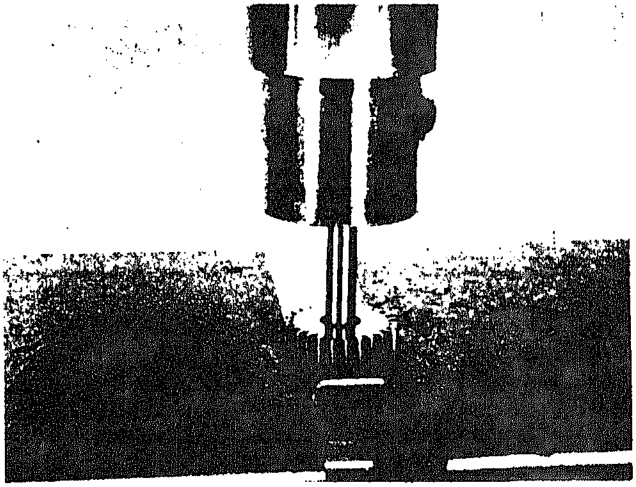


Fig. 506-5 Removing gear from weight carrier F540

If removed, press on gear. Do not press against weights as weight pins may be damaged. Press against end of the carrier shaft.

The rough beveled edge of gear goes toward carrier weight and the smooth side goes toward the bushing.

Slip governor carrier bushing on the carrier shaft with flanged end of bushing next to gear and secure bushing with snap ring.

Welded Governor Weight Carrier Pins

Welded governor weight carrier assemblies are now available. The weight carrier pins and weight carrier shafts have been replaced with 1/4 inch diameter hardened weight carrier pins, welded to the wall of the carrier housing. Welding this assembly provides a stronger, more reliable part than the previously used swaged pin type. These pins can not be replaced. Fig. 506-6.

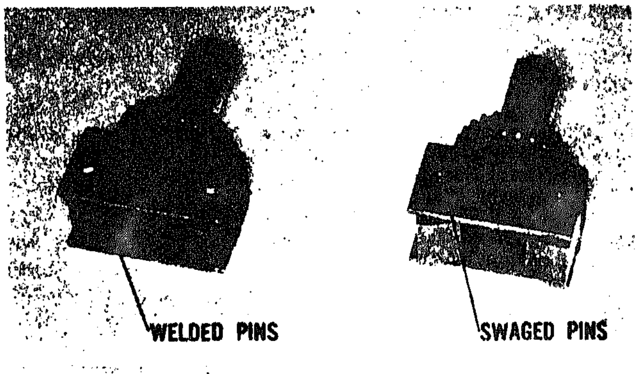


Fig. 506-6 Welded and swaged governor carrier weight pins F5207

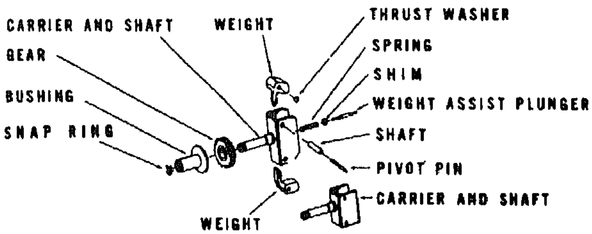


Fig. 506-4 Governor carrier weight assembly—exploded view F5145

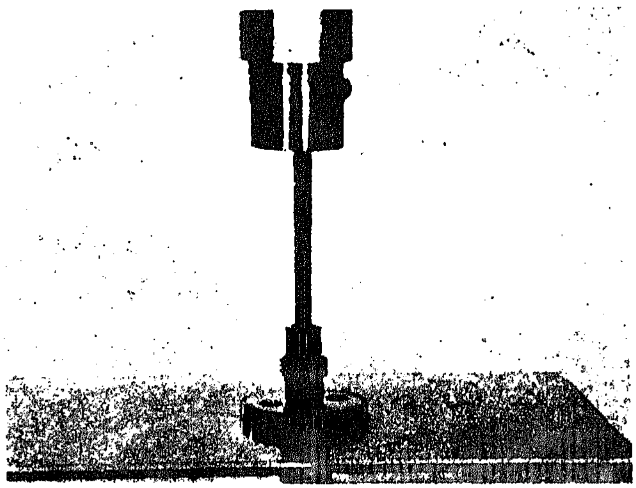


Fig. 506-7 Press tachometer drive gear and governor drive gear F5146

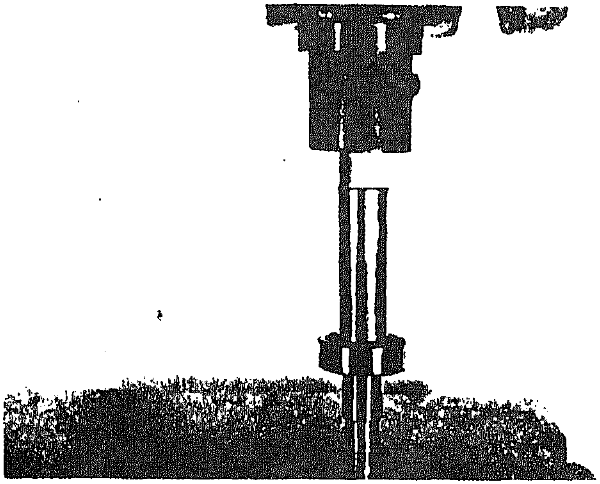


Fig. 506-8 Pressing drive bearing on shaft F541

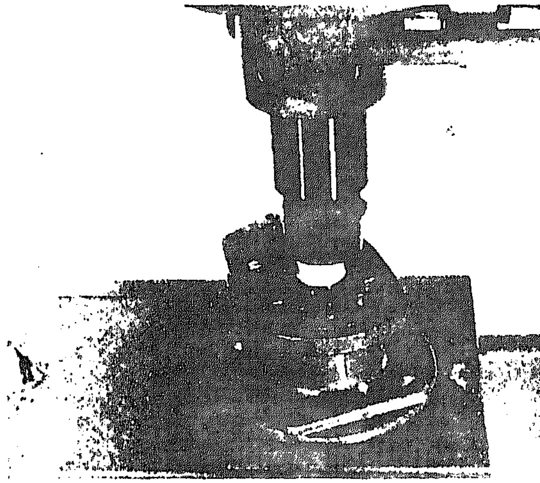


Fig. 506-10 Installing drive cover oil seal

Drive Shaft

Disassembly

1. Press tachometer drive gear and governor drive gear from drive shaft. Fig. 506-7.

   Note: Press away from bearing because shaft has a shoulder under bearing.

2. Press drive bearing from shaft only if bearing is rough or shaft has worn grooves.

Assembly

1. If bearing or shaft is replaced new, Lubriplate shaft and press bearing over shaft, pressing against inner race of bearing. Fig. 506-8.

2. Press governor drive gear to drive shaft bearing over shaft.

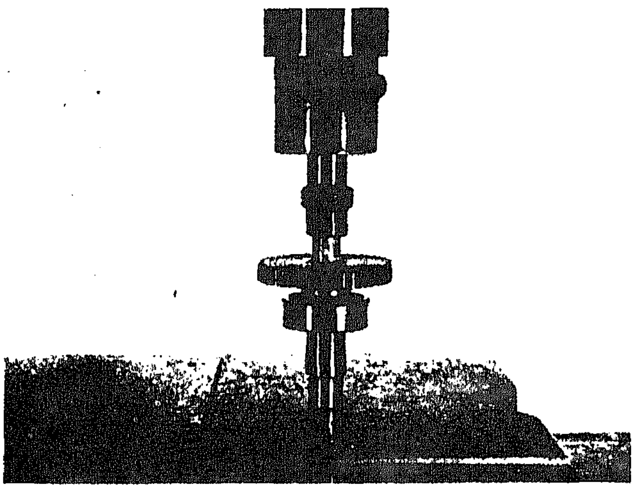


Fig. 506-9 Pressing tachometer gear on drive shaft F542

3. Lubricate shaft and bore before pressing tachomet gear on shaft and against governor drive gear. Fig.

   Note: Check gear to make sure it matches with tac gear to give proper rotation see Page 5-3-4. Fig.

4. Check to see if parts are firmly seated.

5. Insert snap ring between ball bearing and govern gear.

Drive Cover

Assembly

1. Clean all parts thoroughly with mineral spirits or eq

2. Press first oil seal into drive cover with lip toward of pump, and press second oil seal into drive co sealing lip toward inside of fuel pump. Seals spaced so the "telltale" hole is not covered. Fig.

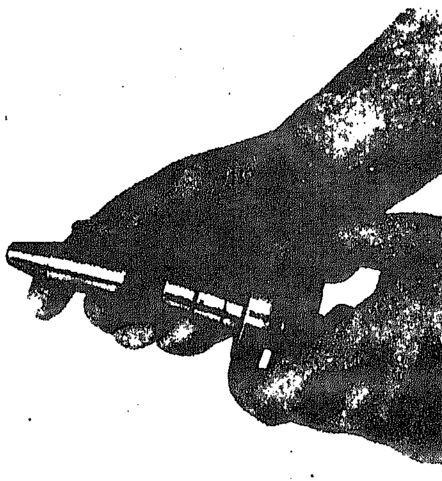
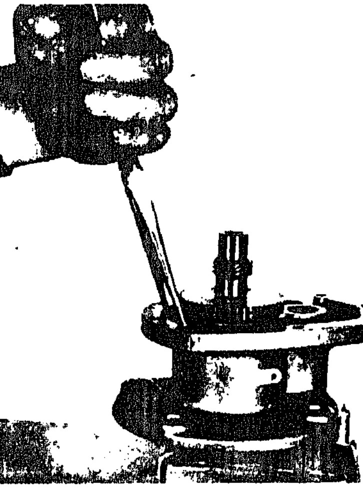


Fig. 506-11 Assemble ST-419 oil seal tool over main shaft



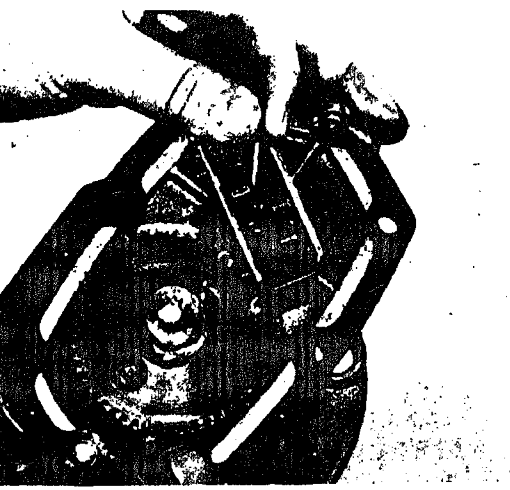
Securing snap ring in groove F544

ST-419 Assembly Tool and install tool over main g. 506-11. Press main shaft assembly into front d through seals. Secure snap ring in cover Fig. 506-12.

/ and press coupling into position on drive shaft. v and straight.

tainer flatwasher, lockwasher and capscrew to tighten in place. Hold coupling or main shaft in a wed vise while tightening.

t cover in boiling water for 1½ to 2 minutes. Coat carrier bushing with Lubriplate, and press as- nto front cover. Mesh gears to avoid damage to e bushing shoulder must seat against housing. eight assembly to be sure it will turn completely in If weight assembly will not rotate it may be neces- rind the housing so the weights will rotate freely.



F545

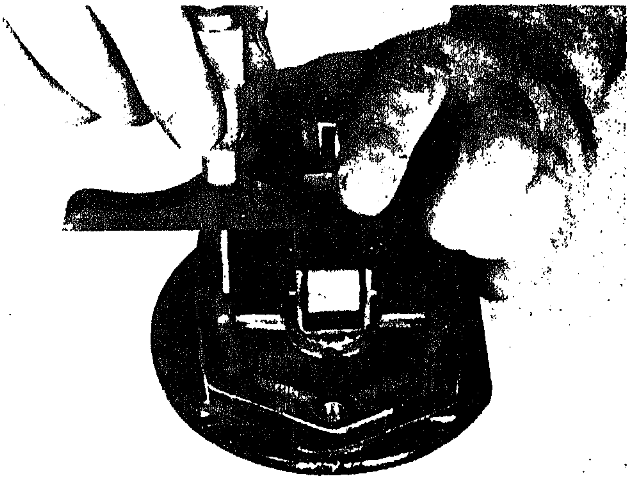


Fig. 506-14 Measuring assist plunger protrusion F546

Caution: Do not press against weights. Press against center of weight carrier shaft.

7. Install shims, spring, and governor assist plunger between governor weight and into bore of governor weight carrier shaft. Fig. 506-13.

Caution: Always check and assemble weight assist plunger with smallest end of plunger to weights. This will prevent weights from sticking. Governor assist plunger is used only on PT (type G) fuel pumps.

8. Use enough shims back of spring to make governor assist plunger protrude above gasket face of front cover. Gauge protrusion with a dial depth gauge having a base approximately 4 inches long.

Note: Refer to calibration data Bulletin No. 983525 and 983533 for weight assist protrusion pertinent to pump being rebuilt.

a. Place one leg of the depth mike base of pedestal across the carrier walls and measure down to the front cover gasket surface (no gasket). Fig. 506-14. Move the depth mike to the opposite side of the carrier and again measure to the front cover gasket surface directly across the cover from the previous measurement (do not turn carrier or cover). Average these two measurements. This procedure is necessary to eliminate any possible influence of uneven carrier wall heights.

b. Position the depth mike across the carrier directly over the weight assist plunger. Measure down to the plunger. Do not depress spring.

c. Subtract "B" from the average determined under "A". The result is the weight assist protrusion. If weight assist protrusion is below specifications, (see Fuel Pump Calibration Data) add shims. If the weight assist protrusion is above specifications, remove shims or grind the exposed end of the weight assist plunger (grind only if no shims are being used).

PT Fuel Pump Group

The governor spring pack consists of the idle and max
or high-speed springs, plungers, adjusting screw and s
The springs control engine speed and adjustment
made by the shims or adjusting screw.

Governor Spring Pack—Unit 507

Standard Automotive Spring Pack

Disassembly

The "Automotive" or idling and high speed mechanical governor is standard on most engines. Fig. 507-1.

1. Remove capscrews, lockwashers and flatwashers securing governor spring-pack cover to main housing.
2. Lift off cover and discard gasket. Fig. 507-2.
3. Remove snap ring which holds governor spring pack in sleeve with a pair of snap ring pliers.
4. Remove high-speed spring, spring retainer and shims from spring-pack housing.
5. Remove idle-spring plunger guide, idle spring or springs, idle spring plunger, and spring rest washer. Fig. 507-3.

Assembly

1. PT (type G) Fuel Pump: Assemble screw into plunger guide, place small copper washer over screw point inside plunger guide. Fig. 507-4. Place small idle spring into plunger guide and place idle plunger (button) against spring in plunger guide. Fig. 507-5.

   Note: A new improved idle plunger is now being used. When assembling governor spring pack the new plunger should be used. Fig. 507-6. The size of this counterbore changes with different engine models. See pump calibration data for correct plunger to use. The plunger controls maximum fuel pressure produced by the fuel pump.

   PT (type R) Fuel Pump: Assemble screw into plunger
   place small washer over screw point and place bot
   springs into plunger guide and place idle spring p
   over idle springs **inside guide plunger**. This idle
   plunger is not counterbored.

2. Place the maximum-speed spring Table 507-4 over th
   of plunger guide and place shim against spring, inst
   tainer and snap ring securing assembly into go
   sleeve. Fig. 507-7.

   Note: There are different maximum-speed springs av
   and each is identified by color stripes. See tabulati
   section.

   Note: Shims are available in .005, .007, .010 and .02
   thickness. The final number of shims must be deter
   during fuel pump calibration. See Unit 511
   on calibration.

3. Install the spring-pack cover and gasket. Install caps
   and washers securing cover to housing.
4. Install lockwire, twist up tight and snap seal over loc

Mechanical Variable Speed Governor PT (typ

The Mechanical Variable Speed (MVS) governor is m
ed on top the fuel pump housing over filter scree
sembly, shut down valve assembly and prime plug loc
on an Automotive PT (type G) fuel pump. See Fig.

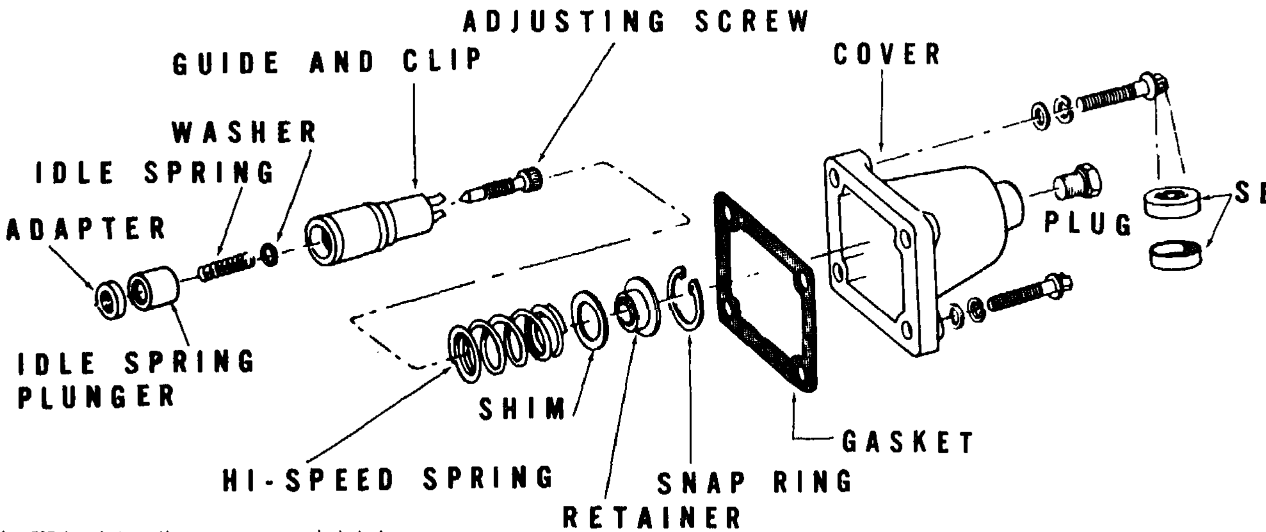
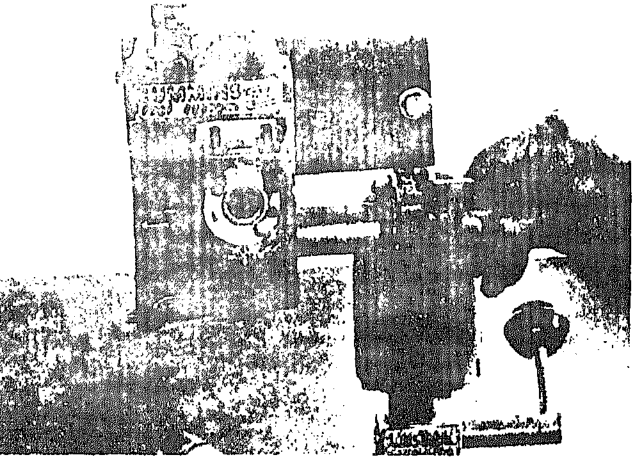
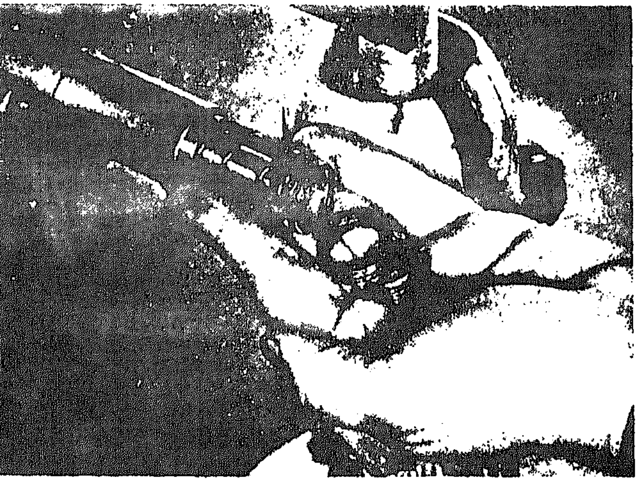


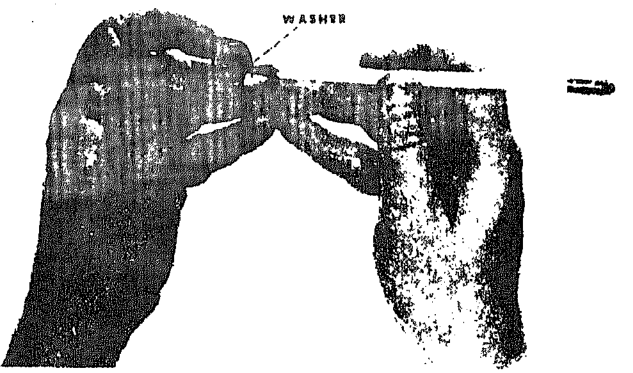
Fig. 507-1 Automotive governor—exploded view



ig. 507-2 Removing spring pack cover F509



ig. 507-3 Removing spring pack assembly F510



ig. 507-4 Installing washer over plunger F558

Fig. 507-5 Installing governor plunger F559

Fig. 507-6 Governor idle plungers F5149

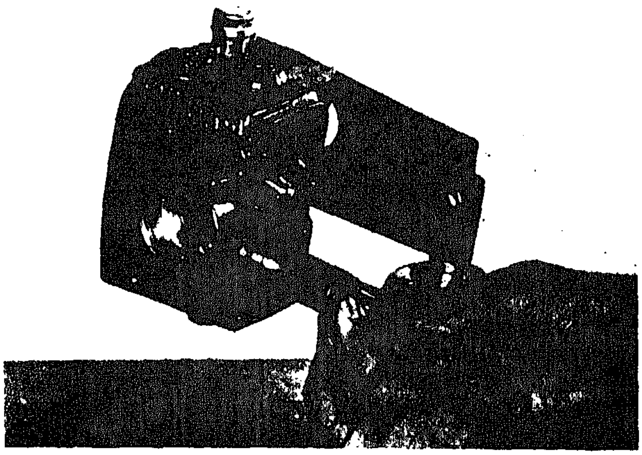


Fig. 507-7 Installing spring pack snap ring F560

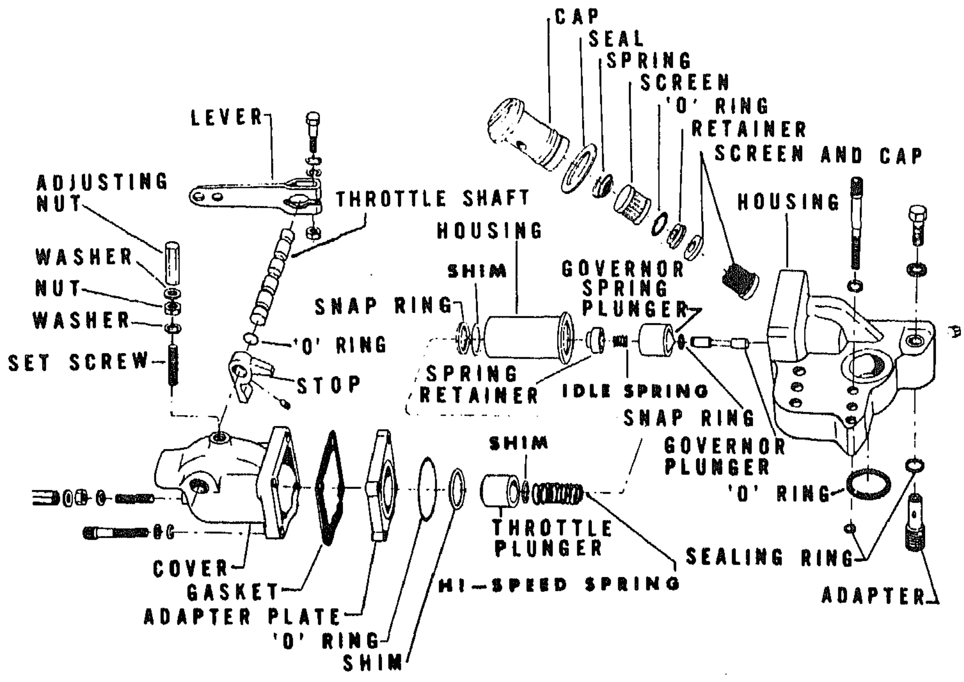
Disassembly

1. Remove filter screen assembly which is made up of cap, "O" ring, spring, upper screen retainer, retainer "O" ring and lower screen.
2. Remove capscrews and washers securing MVS governor to main housing. Lift off governor and discard "O" rings.
3. Screw adapter from top of main housing if damaged.
4. Remove capscrews, lockwashers and flatwashers securing cover to governor housing. Lift off cover and discard gasket.
5. Remove cover to housing plate. Discard "O" ring.
6. Remove high speed spring, plunger and shims.
7. Remove snap ring from plunger housing.
8. Remove shim (or shims) from plunger housing.
9. Remove spring retainer, idler spring and spring plunger.
10. Remove small snap ring and small plunger.
11. Remove set screw securing governor stop on throttle shaft. Pull throttle shaft from cover and discard "O" rings.

Governor Barrel Replacement

1. The aluminum housing should be lightly scribed as shown in Fig. 507-9. This will facilitate alignment of the fuel vent hole of the housing and the vent hole in the new barrel to be installed.
2. Remove the 1/8 in. N.P.T.F. pipe plug from opposite en housing so a .339 inch diameter rod may be inserte press out the governor barrel. Heat housing and b assembly in boiling water for 1½-2 minutes or in an ove 325-350 °F. Press barrel from housing.
3. After removing the governor barrel, the aluminum gove barrel housing bore should be visually inspected for cra pits, scores, or other defects. In the event such def are found, the housing should be discarded.
4. Scribe the new replacement governor barrel as show Fig. 507-9. Scribe line should pass through the cente plunger bore and the center of the 1/8 in. diameter fuel hole.
5. Heat the aluminum housing in boiling water or in a 350°F. over.
6. Coat the outside diameter of the barrel with "STP" similar lubricant.
7. Press the barrel into the housing with scribed marks al ed. Scribe marks must align with .040 inch to assure dexing of the vent holes.

Note: When installing the governor barrel into the hea housing, the pressure applied to governor barrel should be released for 15-20 seconds after the governor barre pressed into the housing. Tests have indicated that continued pressure is necessary to make certain the en ing flat face of the governor barrel maintains contact the housing when both the housing and barrel have coo There is a tendency for the governor barrel to "pop approximately .010-.030 inch out of the heated alumi housing.



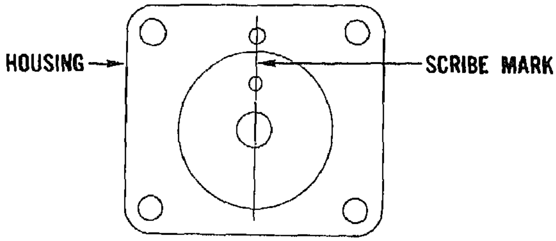


Fig. 507-9. Scribe barrel and housing for alignment F5209

Oversize MVS governor plungers released for service replacement only and the current MVS governor plungers which are applicable for production or service are indicated in table 507-1.

It must be noted that the current governor barrel used for production service can be differentiated from the old, no longer current, governor barrel by examining the flat surface that is exposed when the barrel has only one small

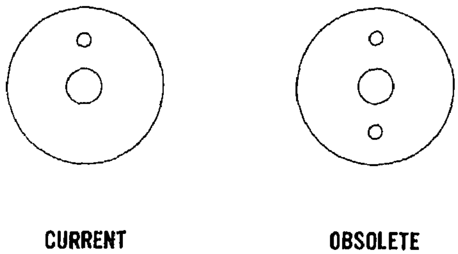


Fig. 507-10. MVS. Governor barrel F5208

vent hole adjacent to the larger governor plunger hole, whereas the obsolete barrel has two vent holes adjacent to the governor plunger hole. When these obsolete barrels are encountered, they should be discarded. The current barrel is machined from harder material and will provide more satisfactory service life. Fig. 507-10.

Cleaning And Inspection

Replace shaft bushing if worn beyond "O" ring sealing capability. Bushing I.D. should be 0.560/0.561 after assembly

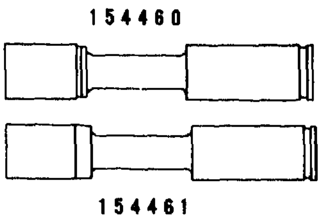


Fig. 507-11 MVS governor plungers F5150

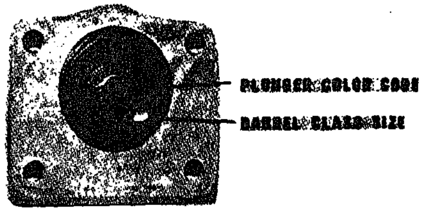


Fig. 507-12 PT (type G) MVS governor plunger and barrel F5151

2. Wash parts in a solvent that is not harmful to aluminum.
3. Inspect parts for scoring, pitting and wear.
4. Check plunger to barrel clearance. It should be 0.0001/0.0005 inch. Oversize plungers are available. See Table 507-1 below. Fig. 507-11.

Table 507-1: Governor Plungers

Part Number	Class Size	Diameter Inches	Color Code
154460	0	0.31140/0.31159	Red
154463	1	0.31160/0.31179	Blue
168906	2	0.31220/0.31239	Green
168907	3	0.31250/0.31269	Yellow
154461	0	0.31140/0.31159	Red
154462	1	0.31160/0.31179	Blue
168908	2	0.31220/0.31239	Green
168909	3	0.31250/0.31269	Yellow

Note: Color code is marked on end of plungers. Barrel size is etched on end of barrel. Fig. 507-12.

Assembly

1. Install snap ring on plunger and insert plunger in main housing. Plunger must drop freely of own weight into barrel.

   Note: If fitting oversize plunger to worn barrel or if new plunger does not drop freely into new barrel it will be necessary to lap the plunger to the barrel. Do not over do this operation. To much clearance increases throttle leakage and results in slow deceleration.

2. Install new "O" rings on throttle shaft and insert shaft in cover through throttle stop and secure stop with set screw.
3. Slide plunger housing into plate and place assembly up against the governor barrel. If housing is loose in plate, add shims between housing and governor barrel until housing is tight and plate is spaced .003/.006 inch from barrel and sleeve assembly. Retain remainder of shims until later in calibration.
4. Install large snap ring in groove inside plunger housing.
5. Install 0.030 inch of shims into housing from flange end so they seat on snap ring.

Note: Too few shims will result in stalling or too little throttle leakage. Too many shims will cause slow deceleration or excessive throttle leakage; therefore, the number of shims may vary from the 0.030 total specified after engine is started, although experience indicates 0.030 is correct in most cases.

6. Slide plunger, spring and shims (usually about 0.100 inch of shim) into housing from rear end. Table 507-4.
7. Slip spring and guide into plunger.
8. Place gasket over cover and position plate on gasket.
9. Carefully slide housing with springs and plungers in plate.
10. Install "O" ring into plate groove; add shims as determined in Step 3 and tighten spring pack assembly to housing with capscrews, lockwashers and flatwashers.

Part Number	Color Code	Replaces	Wire Diameter	Number Coils	Pounds Load @ Inches Length	Free Length
Maximum or High-Speed Springs:						
*143247	Yellow		.092	7.44	17.72/16.36 @ 1.00	1.487
143248	Yellow/Green	70711	.092	7.94	16.20/14.96 @ 1.00	1.487
143249	Yellow/White		.086	7.10	14.68/13.56 @ 1.00	1.487
143250	Red/White	70711A	.086	7.69	13.17/12.15 @ 1.00	1.487
*143251	Blue/Brown	70711B	.086	8.43	11.65/10.75 @ 1.00	1.487
143252	Red		.080	7.64	10.13/9.35 @ 1.00	1.487
143253	Red/Yellow	70711C	.080	8.64	8.61/7.95 @ 1.00	1.487
143254	Red/Brown	135158	.072	7.46	7.09/6.55 @ 1.00	1.487
143255	Red/Green	*70711D	.072	8.99	5.57/5.14 @ 1.00	1.487
143256	White/Blue	70711E-F	.062	7.49	4.05/3.74 @ 1.00	1.487
*144478	White		.086	7.69	19.92/18.40 @ 1.00	1.737
*144479	Green		.086	8.43	17.63/16.27 @ 1.00	1.737
*144490	Orange		.080	7.64	4.93/4.55 @ 1.00	1.237
*144491	Light Blue		.080	8.64	4.19/3.87 @ 1.00	1.237
*147292	Brown		.092	7.00	16.02/14.78 @ 1.00	1.405
147293	Orange/Yellow		.092	6.65	13.72/12.68 @ 1.00	1.322
147294	White/Brown		.092	6.32	11.21/10.35 @ 1.00	1.245
147295	Orange/Red		.092	6.05	11.58/10.69 @ 1.00	1.237
147296	Brown/Green		.092	5.80	12.31/11.37 @ 1.00	1.237
153235	Green/Orange		.080	8.64	6.40/5.90 @ 1.00	1.362
153236	Green/Blue		.086	7.69	9.78/9.04 @ 1.00	1.362
153237	Blue/Yellow	125498	.086	8.43	8.66/7.99 @ 1.00	1.362
153238	Blue/Red		.080	7.64	7.52/6.95 @ 1.00	1.362
70711-G	Orange/White		.054	5.5	1.82/2.07 @ 1.187	
70711-H	Lt Blue/Orange		.054	6.5	1.50/1.71 @ 1.187	
70711-J	Lt. Green/White		.051	6.25	1.21/1.39 @ 1.187	
70711-K	Orange/Lt. Green		.047	7.25	0.78/0.89 @ 1.187	
157059	Blue/Orange		.092	6.32	20.75/22.03 @ 1.00	1.487
177629	Brown/Orange		.102	6.10	19.3/21.3 @ .945	1.270

Formerly color coded — 143247 Yellow/Black, 143251 Red/Black, 144478 Black/White, 144479 Black/Green, 144490 Black/Orange, 144491 Black/Blue and 147292 Black/Brown.

Part Number	Color Code	Replaces	Wire Diameter	Number Coils	Pounds Load @ Inches Length	Free Length
MVS AND SVS Governor Springs:						
53240	None (Idle)		.044	5.5	4.10/3.70 @ .295	.415/.445
09690	Pink		.080	8	18.5/15.1 @ 1.12	1.436/1.356
09689	Gray		.080	8.5	16.3/13.3 @ 1.12	1.424/1.344
09688	Brown		.080	9	14.1/11.5 @ 1.12	1.410/1.330
0822	Green		.080	9.5	12.65/10.25 @ 1.12	1.398/1.318
09687	Yellow		.080	10	11.2/9.2 @ 1.12	1.387/1.307
09686	Blue		.072	8.5	8.03/6.57 @ 1.12	1.358/1.278
0821	Red		.072	10	8.91/7.29 @ 1.12	1.435/1.355
07787	Yellow/Blue		.072	12.5	8.75/7.45 @ 1.12	1.522/1.442
01002	White		.063	11	6.43/5.47 @ 1.12	1.554/1.474
10461	Purple		.063	12.5	5.72/4.88 @ 1.12	1.568/1.488
10460	Orange		.063	14.5	4.97/4.23 @ 1.12	1.578/1.498
05422	Black		.054	11.5	3.35/2.85 @ 1.12	1.548/1.468
18128	Black/White		.054	14	2.42/2.84 @ 1.12	1.598/1.518
43849	Yellow (Idle)		.025	9	2.38/2.62 @ .325	.635/.665
53232	Blue		.086	7.10	6.60/7.10 @ 1.00	1.237
dle Springs:						
44195	None		.032	12	0.69/0.85 @ .955	1.025
38810	None		.032	7	0.39/0.49 @ .418	.525
38811	None		.032	12.5	0.58/0.92 @ .850	.918

ote: 138810 and 138811 used only in fuel pumps without weight assist.

Part Number	Color Code	Replaces	Wire Diameter	Number Coils	Pounds Load @ Inches Length	Free Length
eight Assist Springs:						
43847	Blue		.028	9.75	3.30/3.70 @ .325	.569/.599
3848	Brown		.030	9	4.17/4.83 @ .325	.514/.544
3849	Yellow		.025	11	2.38/2.62 @ .325	.635/.665

PT Fuel Pump Group

The fuel tanks and lines act as the vehicles to carry fu to the fuel pump and from the fuel pump to injectors. In a cases restrictions should be kept at the lowest possib value.

Fuel Lines and Tanks—Unit 509

Fuel Supply Tank

The fuel supply tank with the PT fuel systems serves a dual purpose. First it contains the fuel supply and second, it acts as a temperature control, it receives fuel from injector drain manifold. Fuel which circulates through the injectors carries heat from injectors back to tank. Under cold weather conditions this heated or warm fuel will aid in prevention of frozen fuel lines.

The following tank and piping instructions refer to Figs. 509-1 thru 10 shown on succeeding pages:

1. Venting arrangements shown are representative of conditions required for separation of liquid and fumes coming from return lines to tank. In installations where use of an "air dome" is necessary, an additional vent must be provided. This air dome must be at least 5 inches high and 2½ inches I.D. A vented filler spout of size equal to the air dome may be used provided the vent hole is ⅛ to ¼ inch in diameter. Air vent must be below level of injector in all cases except where an overhead tank is used.

2. To avoid overflow of fuel in hot weather fuel tank should be designed so it can be filled to only 95% of its total capacity.

3. The fuel filter should be readily accessible and should be located between the bottom of the fuel tank and level of fuel pump inlet connection as close to the tank as accessibility will permit. Avoid locating higher than fuel pump if at all possible. It is best to locate filter under hood if possible for cold weather protection.

4. Make sure all suction line connections to pump are air tight, with outlet from tank in center and ¾ inch above bottom of tank. This may be a bottom connection or a pipe from any location reaching to bottom center of tank.

5. Injector drain connection in tank should be located near

6. A sump should be provided in tank to drain sediment ar water. Fig. 509-6.

7. For installations which are subject to I.C.C. regulatior it is recommended that fuel line or vent location and pr tection be made to conform with I.C.C. specifications.

8. An overhead tank installation should not be used under a condition where fuel might possibly syphon back to the i jectors. Use with a float tank, with filter located betwe pump and float tank.

9. For best results in any installation tank location should n be more than 8 feet below the pump.

10. Fuel should be drawn from tank at least ¾" above botto to avoid sucking sediment or water.

Fuel Lines

See table 509-1 for line sizes (hose or steel tubing) used in fuel system. Hose used should consist of a seamless synthetic rubber inner tube reinforced with fabric braiding and wire braiding, and covered with a synthetic rubber impregnated oil resistant fabric braid or rubber coating. The hose should be capable of handling fluids ranging in temperature from —40°F. to 300°F.

Table 509-1: Fuel Lines

Fuel line Usage	Hose Size	Tube Size	Maximum Restriction
Fuel suction	No. 10	5/8" O.D.	4" Hg. (clean filter)
Injector return	No. 8	1/2" O.D.	1" Hg.
PT (type R) fuel pump return	No. 6	3/8" O.D.	—
PT (type G) Integral gear pump bleed on cooling kit	No. 4	—	—

Eliminating Fuel Tank Condensation

At the end of the work period the fuel tanks should be [illegible] to minimize tank condensation. A small amount of moisture from condensation and engine storage is unavoidable. Alcohol will absorb moisture from fuel. Moisture or traces of water can be removed from fuel tanks by adding one pint of pure anhydrous (waterless) or methanol (wood) alcohol to every 50 gallons of fuel. Be certain alcohol container is tightly closed during storage. Alcohol will also absorb moisture from air if the lid isn't air tight, thereby making it useless as a drying agent.

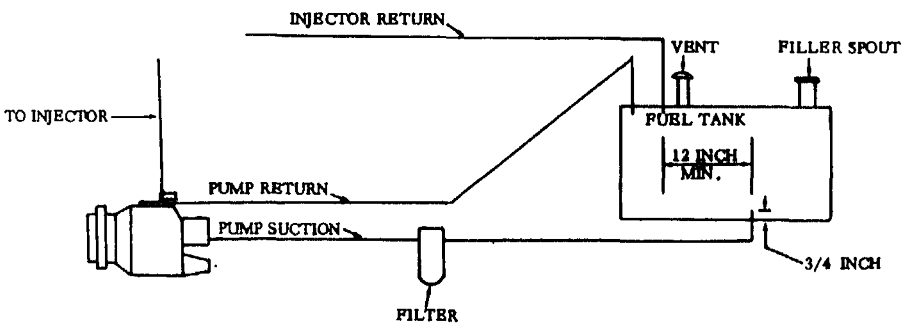


Fig. 509-3 Single fuel tank

PT Fuel Pump Group

The pump assembly requires all parts to be dirt free, a the actual operations performed with the utmost care, insure proper and trouble-free performance.

Fuel Pump Assembly—Unit 510

Vise And Holding Fixture

Mount the fuel pump housing on Holding Fixture ST-546 and Swivel Vise ST-302.

Tachometer Drive

1. Install tachometer drive assembly into fuel pump main housing. Press assembly into housing using ST-430 Mandrel.
2. Press oil seal on the tachometer drive with sealing lip down. Seal must seat on the drive bushing.
3. Assemble tachometer cover and new gasket to the fuel pump housing. Fig. 510-1.
4. Install screws and washers in cover.

Filter Screen

1. Assemble the filter screen assembly into the housing, the hole in the bottom retainer goes down. Fig. 510-2.
2. Install "O" ring using grease to hold in place.
3. Position spring and tighten cover in place. Torque cap 25/30 ft. lbs. Over-tightening is not necessary or desira

Note: A new stronger, more reliable filter screen has b released. It may be identified by the two sizes of wire a ripple appearance.

Note: MVS governors and special electric governors c tain two screen assemblies. See Section 502.

Governor Spring Pack

Automotive Governor

1. PT (type G) Fuel Pump: Assemble screw into plun guide, place small copper washer over screw point ins plunger guide. Fig. 510-3. Place small idle spring i plunger guide and place idle plunger (button) agai spring in plunger guide. Fig. 510-4.

Note: A new improved idle plunger is now being us When assembling governor spring pack the new plun should be used. Fig. 510-5.

The size of counterbore changes with different eng models. See pump calibration data for correct plunger use. The plunger controls maximum fuel pressure produc by the fuel pump. All plungers with code number 170

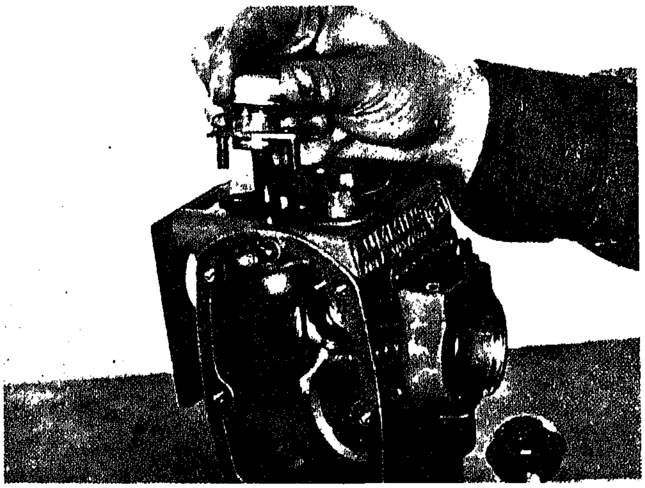


Fig. 510-1 Installing tachometer cover F556

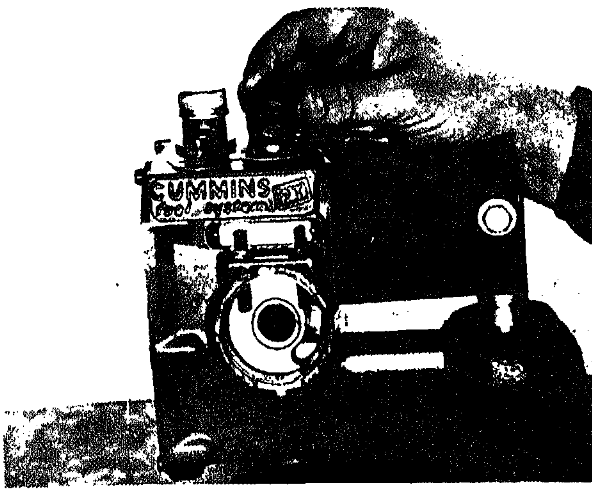


Fig. 510-2 Installing filter assembly

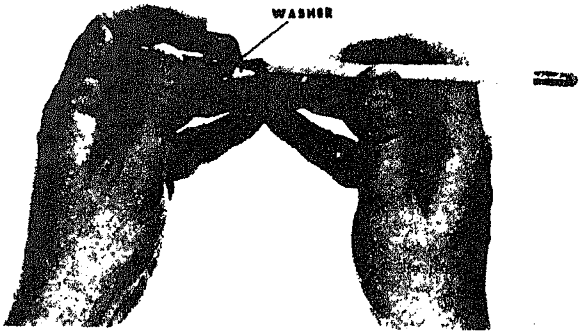


Fig. 510-3 Installing washer over plunger F558

higher require adapter part number 144676.

Place the maximum-speed spring over the rear of plunger guide and place shim against spring, install retainer and snap ring securing assembly into governor sleeve. Fig. 510-6.

Note: *There are different maximum-speed springs available* and each is identified by color stripes. See Section 507 Page 8 for tabulation.

Note: Shims are available in .005, .010 and .020 inch thickness. *The final number of shims must be determined during*

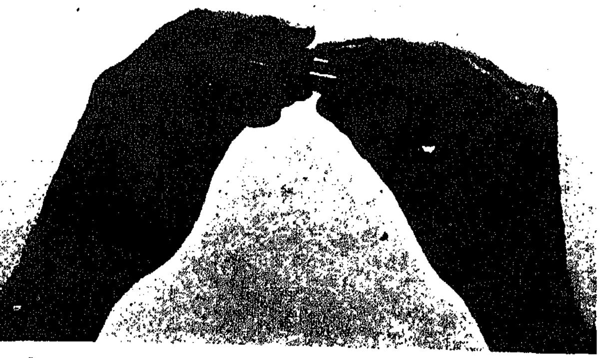


Fig. 510-4 Installing governor plunger F559

Fig. 510-5 Governor idle plunger F5149

fuel pump calibration. See Unit511 on calibration.

3. *Install the spring-pack cover and gasket. Install capscrews* and washers securing cover to housing. Torque capscrews to 90/95 in. lb.

Gear Pump

1. Assemble the gear pump to the main housing using a new gasket. Fig. 510-7. Locate notch for right hand or left hand rotation. For right hand rotation locate notch to upper right hand corner (looking from behind the fuel pump); for left hand rotation locate the notch to bottom left hand corner.

   Note: Use correct gasket and be sure it is positioned correctly.

2. *Install capscrews, lockwashers and plain washers;* torque

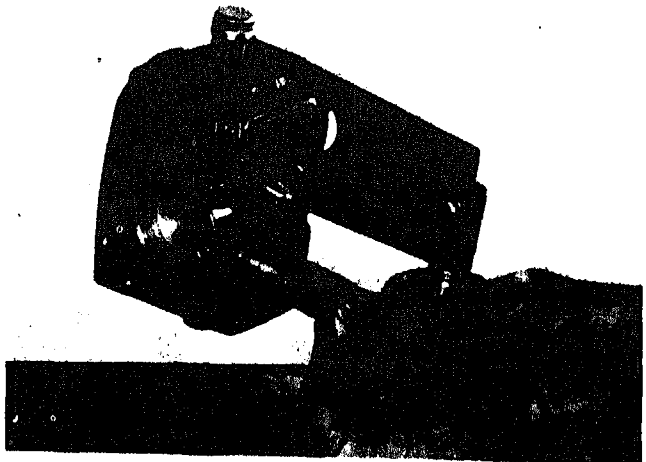


Fig. 510-6 Installing spring pack snap ring F560

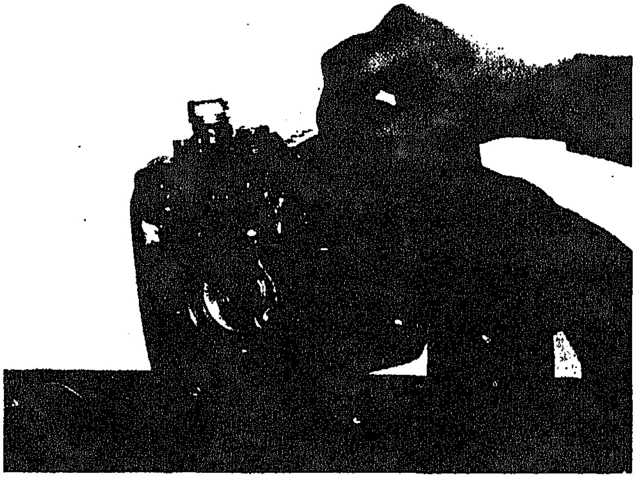


Fig. 510-7 Installing gear pump F561

in increments to 7/9 ft. lbs. Fig. 510-8. Check gear pump rotation freedom.

3. Install fuel inlet connection using a good pipe sealer such as John Crane lead sealer. Use sealer sparingly to keep out of pump. Cover connection to keep out dirt.
4. Install cooling check valve and/or elbow into top of gear pump if used.

Throttle Shaft

Throttle shafts vary with applications. Replace with identical throttle shaft, if replaced. Table 510-1, 2 and 3.

1. Install new "O" ring on throttle shaft using ST-835 Mandrel for ½ inch (ST-422 for larger) shaft to avoid damage to "O" ring. Lubricate in "STP" before assembly. Fig. 510-9.

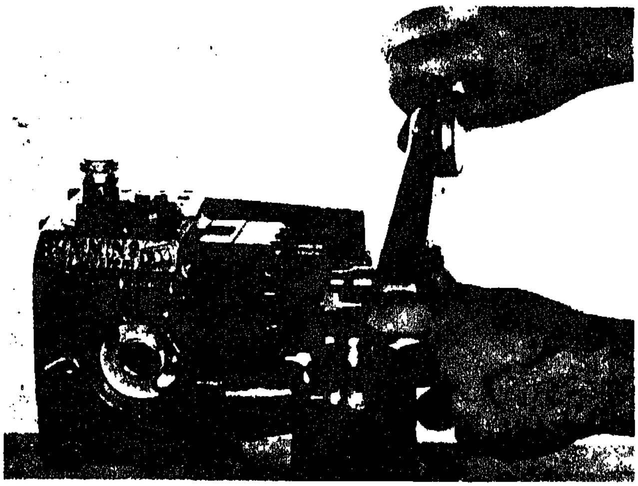


Fig. 510-8 Torquing gear pump capscrews F562

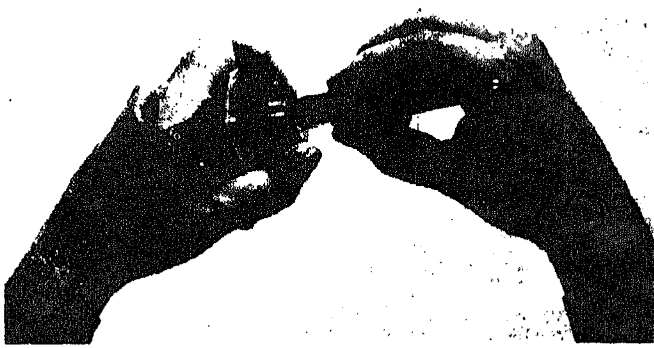


Fig. 510-9 Installing throttle shaft "O" ring F56

2. Install restriction plunger in the throttle shaft, if usec most PT (type G) pumps use this resriction plunger. Torqu plug to 40/55 inch pounds.

   Note: Install enough shims to bring the plunger flush wit the fuel passage leaving it completely open. Fig. 510-1(Some throttle shafts do not have a restriction plunger i them.

3. Insert the throttle shaft in sleeve so the "ears" of the sto are curved downward or if pin is used so open side of pi is down, lubricate with fuel oil.

   Caution: Counterbored port on PT (type G) throttle mus go down,

4. Install the snap ring and lock in the groove in front of th name plate. Fig. 510-11.

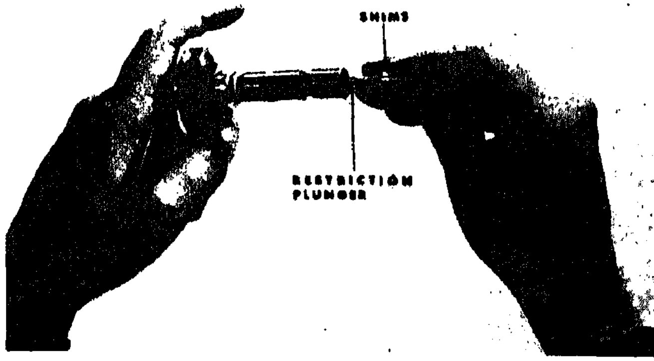


Fig. 510-10 Installing restriction plunger F56

e 510-1: Throttle Shafts 1/2" PT (type G)

ge — Standard, except as noted below: (See Fig. 507-12.)

e	Red	Blue	Green	Yellow	Brown	Black	Gray	Purple
	0	1	2	3	4	5	6	7
No.	149030	149031	149032	149033	149034	149035	161596	161597
e	Red/Gray	Blue/Gray	Green/Gray	Yellow/Gray	Brown/Gray	Black/Gray		
	10	11	12	13	14	15		
No.	169890	169891	169892	169893	169894	169895		
e	Red/Purple	Black/Purple	Green/Purple	Yellow/Purple	Brown/Purple	Black/Purple		
	20	21	22	23	24	25		
No.	169900	169901	169902	169903	169904	169905		

ge — MVS governors:

e	Red	Blue	Green	Yellow	Brown	Black	
	0	1	2	3	4	5	
No.	157940	157941	157942	157943	157944	157945	Solid Shaft
No.	155380	155381	155382	155383	155384	155385	Restricted Shaft

Note: The throttle lever stop in the vehicle chassis should be adjusted so there will be a minimum or negligible amount of collapsing of the throttle lever. Otherwise, the purpose of the spring loaded lever will be defeated as the lever can collapse only so far. Also, if the throttle linkage stop is not properly adjusted, the spring loaded lever may

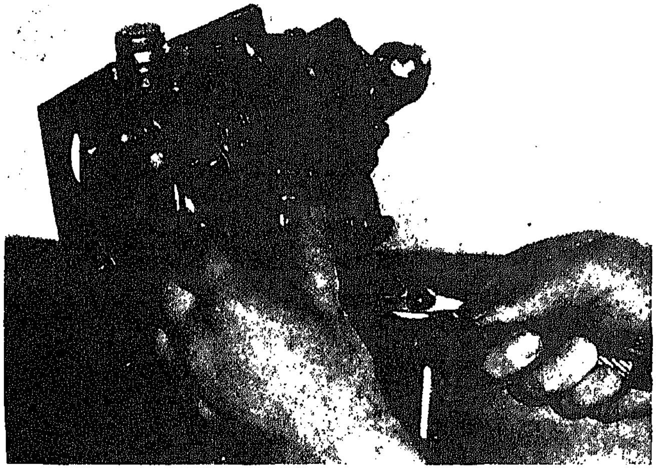


Fig. 510-11 Installing snap ring F565

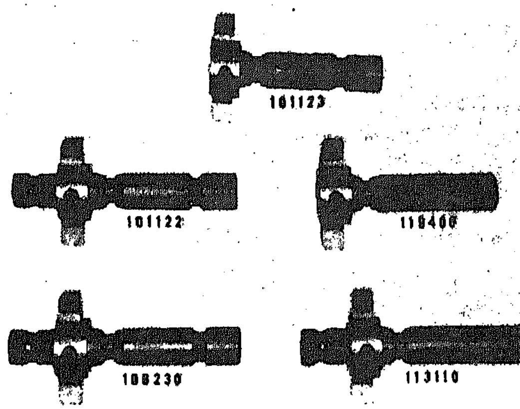


Fig. 510-13 Current PT (type R) throttle shafts

Governor Plunger

Lubricate and install the plunger into barrel. Fig. 510-14. Make sure plunger is correct fit and correct number if replaced. Remark governor barrel if oversize plunger is used, so size of barrel and plunger correspond.

Drive Cover Assembly

Place a new gasket over the drive housing cover dowel pins.

Place the assist plunger in the weight shaft bore with spring and shims, used only on PT (type G) pumps.

Hold the governor weights in to hold the assist plunger while assembling cover to housing, meshing the tachometer gears. Fig. 510-15.

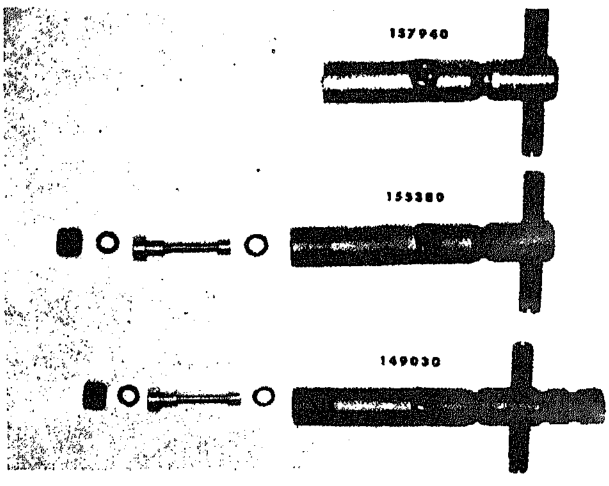


Fig. 510-12 Current PT (type G) throttle shafts F519

Position plunger drive tang horizontally — position carrier horizontally.

Note: The weights straddle the governor plunger dri

4. Assemble the capscrews, flatwashers and lockwashe curing cover to housing and torque to 90/95 inch p

Shut-Down Valve

1. Put grease on the "O" ring and install the shut-down on top the fuel pump housing.
2. Secure with capscrews, lockwashers and flatwashers.

Pulsation Damper

1. Put grease on "O" ring and install damper to the pump.
2. Secure with screws, lockwashers, and flat washers. Torque to 8 ft. lb.

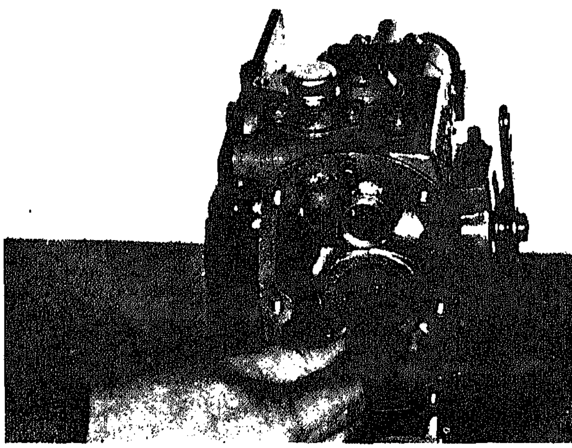


Fig. 510-14 Installing governor plunger

tegral Type PT (type G) Fuel Pump Cooling eature

l PT (type G) fuel pumps have been revised to incorpo-te a new fuel pump cooling feature as an integral part of e gear pump for production engines.

ne small amount of fuel which this new cooling device utes back to the fuel tank, previously was recirculated ternally. Therefore, this method of cooling does not use ny of the normal delivery of the gear pump and present el pump calibration specifications will still apply.

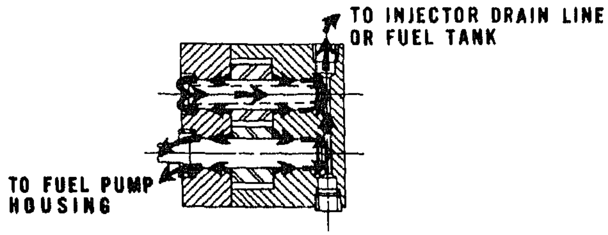
nis bleed fuel is that fuel which flows through and lubri-ates gear pump bearing bores. Previously, this fuel was umped back into the suction side of the gear pump. With e integral bleed gear pump, the lubricating fuel flow rough three gear pump bearings is bled off through an ternal tapped drain hole. The former internal pump illings which permitted this fuel to return to the suction de, have been eliminated. Fig. 510-19.

ne inboard main shaft bearing bore still returns its fuel the gear pump suction. The inboard idler shaft bearing el flows through the hollow idler shaft to the external ain line. As can be seen from the sketch, both outboard ear pump bearings drain externally.

nce three of the bearing bores drain externally, it is ap-arent that both tapped holes in the gear pump housing annot be plugged. Plugging both tapped openings will revent lubricating and cooling fuel flow through the three earing bores and gear pump seizure will occur.

oth ends of the through drain drilling are tapped so that ear pumps can be converted from R.H. to L.H. in the ormal manner.

aution: Under no circumstances should the pump be op-rated with the cooling return flow plugged. This fuel flow necessary to lubricate the bearing surfaces within the ear pump.



1. Fuel pumps with the integral cooling feature may be identified by a 1/8 inch N.P.T.F. hole in the top of the gear pump.
2. If fuel pump is equipped with ~~MVS~~ governor, the MVS spring pack cover (109744) and the adapter plate (148254) *must be reworked to provide sufficient clearance for the* elbow coming from the gear pump. Fig. 510-20.

Note: Step No. 3 must be complete before reinstalling the MVS spring pack.

3. Install a 175836 elbow-check valve in the 1/8 inch drain hole in the gear pump.

Note: The spring-loaded check valve is necessary to prevent the fuel in the pump from draining away and causing hard starting.

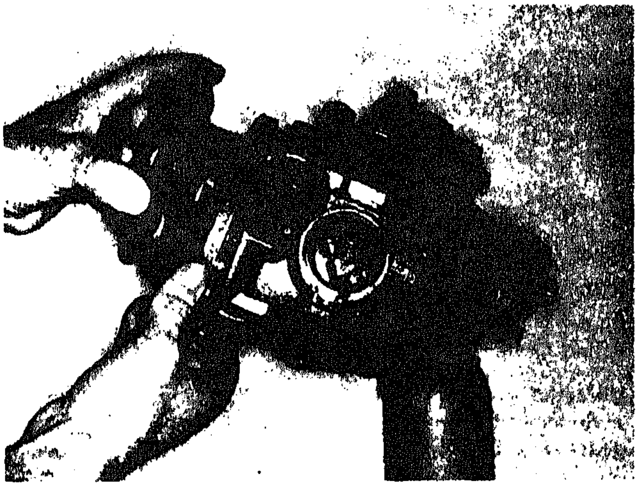
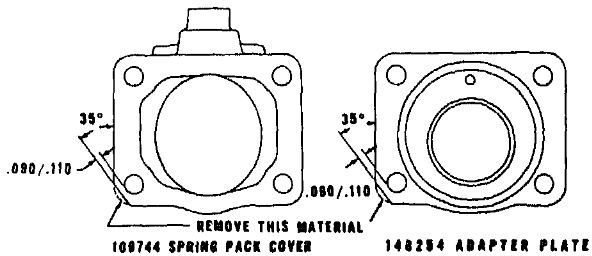


Fig. 510-15 Installing drive cover to main housing F567



PT Fuel Pump Group

The purpose of fuel pump testing and calibration is simpl to make adjustments prior to pump installation on an en gine which will assure engine performance within specifica tions. Test stand calibration then is a time-saving practice The fuel pump could be calibrated or completely adjuste on the engine if you were able to control the load as i done on a dynamometer, but the time required would b prohibitive.

Calibration Instructions—Unit 511

The following checks should be performed if you suspect porosity of fuel pump housings, low gear pump output or excessive leakage of MVS Governor. The gear pump test can only be performed on test stands equipped with a flow meter, ST-775 or ST-848. See following paragraphs for pump mounting to test stand instructions.

Housing Porosity Check

1. Fill fuel pump with clean fuel or test oil.
2. Remove suction fitting at gear pump and install fittings so an air pressure hose may be attached.
3. Air supply hose line must be equipped with a valve and gauge to control air pressure at a maximum of 20 psi.
4. Apply 20 psi air pressure; do not exceed 20 psi or damage to seals may result.
5. Pour fuel or test oil over pump and examine carefully for air bubbles, indicating leaks. Alternately wipe pump or specific area dry and check for wet seepage. Do not use this check for seals.

Gear Pump Test

1. Use a "dummy" fuel pump built up with only the parts required to drive the gear pump, minimum of pump body, with tachometer drive and a complete front cover assembly. If desired a complete fuel pump can be used if the governor plunger and weight assist plunger and spring assembly are removed and pump housing is filled with fuel; this will prevent any possible damage to governor plunger or governor barrel.
2. Install ST-844 gear pump block plate, with gasket on each side, between gear pump and fuel pump body.
3. Remove gear pump damper from gear pump and connect copper line from orifice block to gear pump pressure tap.
4. Connect the fuel suction line to the suction side of the

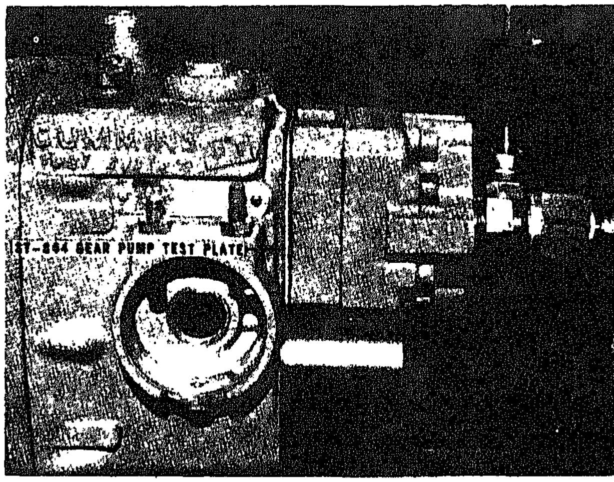


Fig. 511-4. ST-844 gear pump block plate F51

5. Shut off the fuel manifold pressure gauge to prevent dam age from over pressure.
6. The valve in the suction line and the valve controlling th main flow orifice are to be fully open. All other valves mu be completely closed. With the valves in this position, fu will be routed through the manifold orifice.
7. Start the pump drive in the proper direction and run th pump at 400 to 450 RPM. The gear pump must pick up this speed without the aid of priming. Any gear pump whic fails to pick up fuel must be reworked or replaced. The re maining steps of this check need not be made on any pum failing to pick up.
8. Increase pump speed for the following checks:

Gear Pump	RPM	Minimum Total Flov
7/16 inch	2100	495 Lbs./Hr.
3/4 inch	2100	850 Lbs./Hr.
1 inch	2100	1080 Lbs./Hr.
1 1/4 inch	1600	1000 Lbs./Hr.

Any gear pump with delivery below the listed value shou

ote: The minimum total flow requirement will be higher r the NRTO (3/4 pump) and V-12's which are rated over i0 bhp at 2100 RPM. The requirement for reworking or re- lacing these pumps will be the ability to obtain the re- uired fuel manifold pressure on the test stand.

ny gear pump with a delivery above the listed minimum to be considered acceptable for fuel pump operation, nd it can be installed on a fuel pump for proper calibra- on.

he following check should be made if the gear pump de- very is just above the listed minimum described in Step 9.

he unrestricted manifold pressure should be checked for 10/15% higher pressure at rated speed than the manifold ressure. If it is too low or too high it may be necessary to hange idle plunger (button) to give the correct unre- tricted pressure of 10/15% above final manifold pressure.

ote: The idle plunger (counterbore-diameter) may be de- reased in size to increase the amount of pressure avail- ble at the calibration set-point.

aution: Step 10 is to be used only if gear pump is worn reventing it from delivering enough pressure for proper alibration. Never change idle plunger to exceed the 0/15% unrestricted manifold pressure.

IVS Governor Leakage

he following check may be used on fuel pumps with slow eceleration and/or throttle leakage.

lount a fuel pump for pressure source to test stand. This ump must be capable of developing 220/230 psi with test tand manifold valve closed.

lock both sides of a filter cap screen bore with silver oldering.

nsert blocked filter cap and screen assembly in bore of IVS housing.

Vith a suitable plumbing arrangement, tee into the fuel ump test stand manifold line. Connect this line at the 1/8 nch pipe tap hole at the filter cap end of housing.

emove the snap ring from around governor spring in gov- rnor sleeve.

lace the MVS Lever in minimum speed position.

lose the fuel pump test stand manifold valves and raise e speed to near rated speed. Fuel will be discharged om gear pump suction. Solenoid must be manually open or this check. Check the discharge fuel temperature on e test stand temperature gauge.

Vhen the fuel temperature reaches 85/95° F., move the MVS overnor lever to maximum speed position and raise or ower the pump speed until the manifold pressure gauge hows 220/230 psi. Measure the leakage from the solenoid utlet fitting. This leakage must not exceed 10 cc per inute.

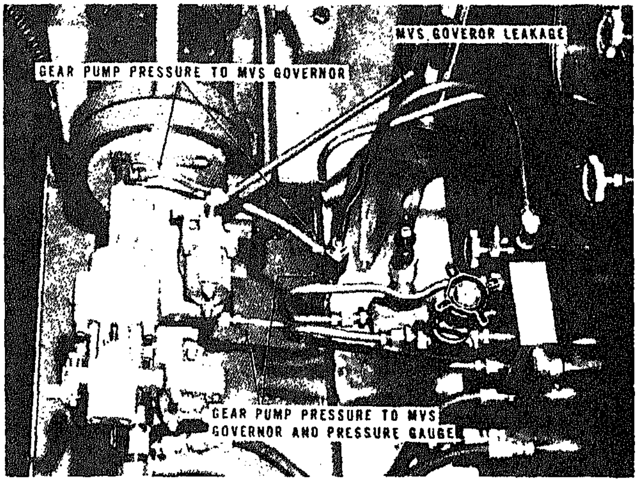


Fig. 511-5. Checking MVS governor leakage F5167

Note: Connect a short length of tubing to the 90° weather-head fitting on the solenoid to act as a spout.

9. If leakage is above 10 cc per minute refit plunger in sleeve and recheck the leakage.
10. Install snap ring back into MVS governor sleeve around governor spring.
11. Remove the filter cap with the silver soldering and install a cap with the side holes open.

Pump Hookup

1. Install the proper drive coupling to test stand, which matches pump drive shaft coupling, so pump being tested may be driven. See Fig. 511-6 and 511-7.

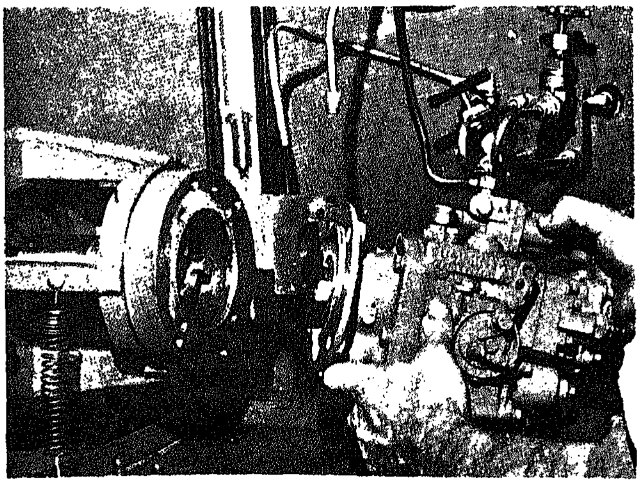


Fig. 511-6. Mounting fuel pump with buffer type drive F5168

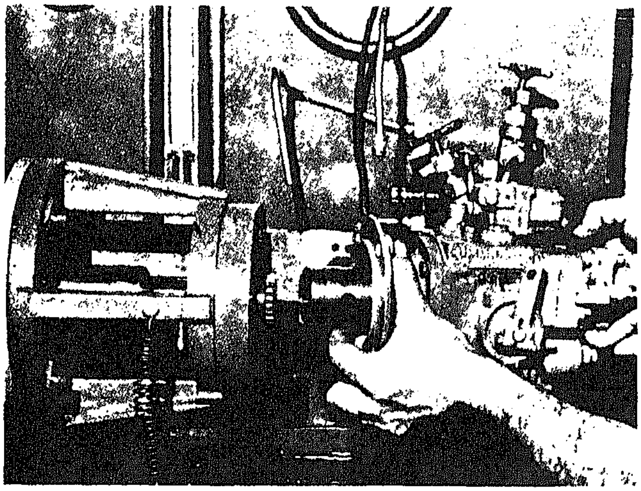


Fig. 511-7. Mounting fuel pump with spline drive F5169

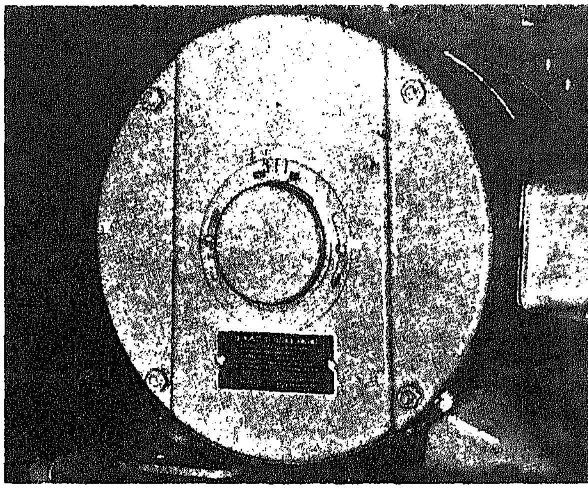


Fig. 511-9. 50 cycle motor brush location to reverse motor F

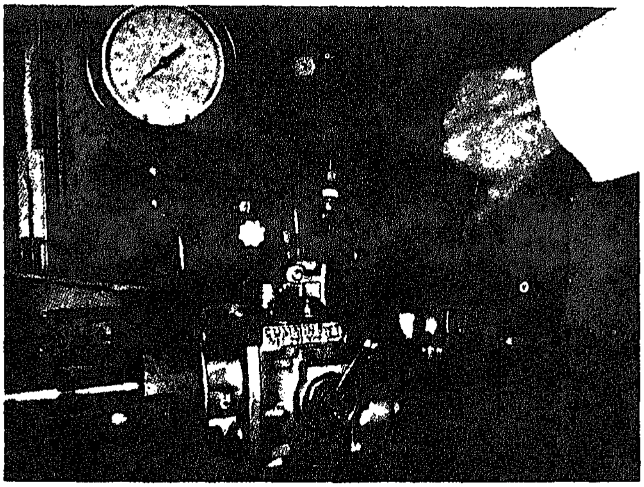


Fig. 511-8. Connect gear pump suction line F5102

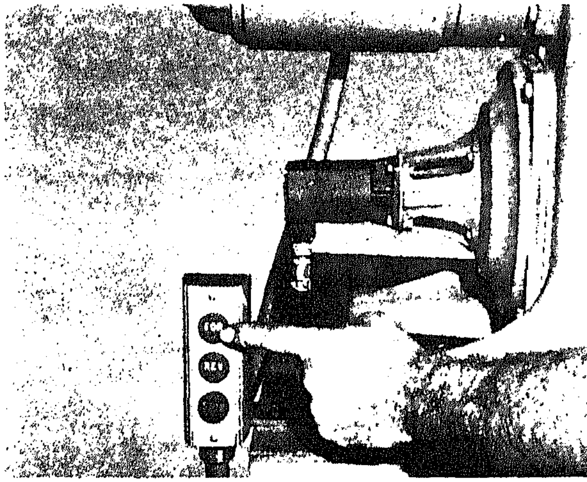


Fig. 511-10. 60 cycle motor reverse button F

Mount fuel pump on the test stand mounting bracket leaving about 1/16 inch between fuel pump coupling and test stand drive coupling.

Squirt some clean test oil into the gear pump inlet hole, so pump will pick up faster, then connect suction line. Fig. 511-8.

Connect the gear pump pressure line to the fuel pump damper, if outlet fitting is present. The gear pump pressure line may also be connected at the 1/8 pipe plug holes on bottom or side of the pump, just before the governor barrel. Never calibrate a fuel pump or check fuel pressure without the fuel pressure damper in place.

. Fill fuel pump housing with clean test fuel through the plug hole on top of pump (fuel inlet fitting on V6-140/V8-185 engines). Reinstall plug or fitting.

. Connect line to fuel pump shut down valve.

a. Use a copper line 5/16 inch O.D. and 24 inches long.

b. Or as an alternate method connect a No. 5 wire brai hose in place of the copper line and remove the line r ning from the orifice block to the manifold pressure gau Plug hole in orifice block. Then install a No. 4 wire brai hose at manifold pressure gauge and connect it into No. 5 hose 3 to 5 inches from fuel pump shut down va The 3 to 5 inches of line below this junction should be inch O.D. copper tubing for ease of plumbing.

7. Connect a No. 4 hose to the cooling bleed check valve pump housing or on gear pump, if used.

Caution: Never operate gear pump having cooling d with the drain plugged.

8. Never remove fuel pressure damper either during testin operation as it will cause erratic pump performance accelerate wear.

Use ST-774 Tachometer at the fuel pump tachometer shaft connection to obtain most accurate speed readings (unless using ST-775 or ST-848 stand).

The ST-848 test stands with 50-cycle current requires a change in motor brush location to reverse motor for left hand fuel pumps. Fig. 511-9. Rotate cover shown to position required by loosening two cover screws.

The ST-848 test stands with 60 cycle current require only that the reverse or forward start button be pressed depending on right or left hand pumps. Fig. 511-10.

Check Pump Name Plate

Former Method of Stamping

Make sure the fuel pump name plate properly describes the fuel pump as it has been calibrated.

The first space is stamped with the number of engine cylinders "12". Fig. 511-11.

The next four spaces gives the engine model designation.

The next six or more spaces on the top line gives the pump serial number, this number should not be changed.

On the second line the letters "GR" stand for PT (governor regulated) fuel pump.

The next four spaces indicate calibration release code "54" numbers and engine model code "CG" letters.

The next five spaces indicate pump speed rating "2000".

The last space is stamped "L" when a left-hand rotation fuel pump is used. Some "V" series engines rotate right hand, but require a left-hand rotation fuel pump.

Current Method of Stamping

The first spaces in the top line are to designate the number of engine cylinders, and the engine model "12VT-825".

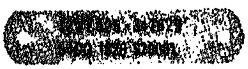
2. The next six or more spaces on the top line give the pump serial number "347629".
3. The first four spaces on the second line designate the code number "54CG".
4. The next four spaces on the second line give the calibration card number "1326".
5. The last six spaces on the second line give the speed rating of the fuel pump and the rotation of the fuel pump, as "L" when a left hand fuel pump is used "S2000L". The "S" indicates standard governor.

Run-In

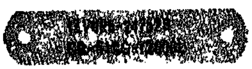
1. Open completely the fuel pump shut-down valve (manual button Fig. 511-12) and flow control valve. Open throttle, wide open position, (secure open with a spring) start and run pump at 500 rpm. If pump does not pick up check for closed valves in the suction line, an air leak or for incorrect rotation of pump.

   Note: Incorrect rotation of pump may cause damage to vacuum gauge.

2. If pump is newly rebuilt or has been opened, run at slightly over rated speed for five minutes to flush, allow bearings to seat and to purge all air from the system.
3. Before starting calibration, check pump fuel flow in the flow-meter for air. If air is present, correct leak before continuing test.
4. Make sure throttle shaft, with restriction plunger, has plunger shimmed so main throttle port is completely open. This is not necessary if the calibration is merely being checked as a trouble-shooting step. Fig. 511-13.
5. Move throttle control lever to full fuel position, it may be necessary to adjust the throttle screws to insure that the fuel port in the throttle is fully open and indexed with the fuel passage in the fuel pump body. It is not necessary to



NEW METHOD



OLD METHOD

Fig. 511-11. Check pump nameplate F5165

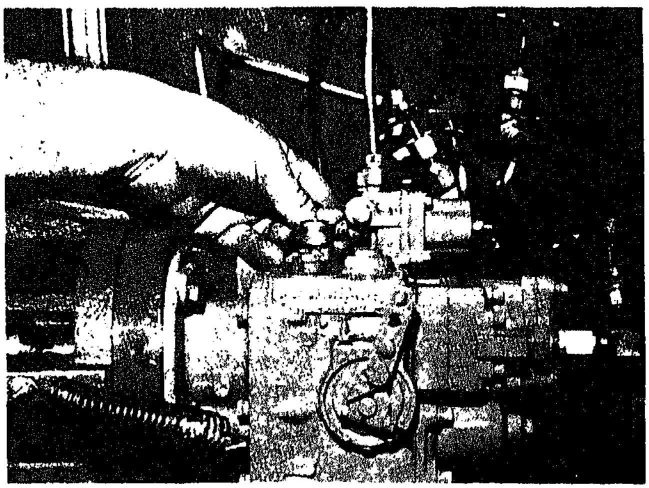


Fig. 511-12. Opening shut-down valve F5171

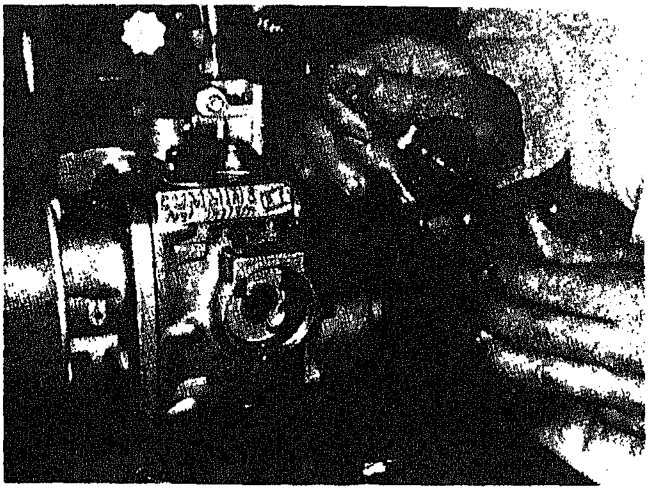


Fig. 511-13. Shim throttle restriction plunger F5104

adjust the throttle screw if the calibration is merely being checked as a trouble-shooting step.

6. With SVS and MVS governors both throttle levers must be in full fuel position.
7. The test oil or fuel temperature must be 90° to 100°F.

Caution: Never set fuel pump to produce a higher horsepower than engine was released for, to do so will void engine warranty, unless approved by the factory through a Cummins distributor.

8. SVS governors are not to be used with power take off speeds below 1100 rpm.
9. Set gear pump at 8 in. hg. vacuum during run in.

Calibration Procedure — Flow-Meter Method

A. Check Pump Seals

1. With test stand operating at 500 rpm, close vacuum valve in fuel pump suction line till vacuum gauge reads 15 inches vacuum. The fuel flow control or needle valve should be open during this check. Fig. 511-14.
2. Put a small amount of Lubriplate or light cup grease over the vent or "weep" hole at mainshaft seal bore of fuel pump front cover. Fig. 511-15.
3. If the lubricant is sucked into the hole at the 15 inch vacuum setting, it is an indication that the seal will not permit proper engine performance and should be replaced.
4. The above check may also be performed on the throttle shaft to check the shaft "O" ring. Apply lubricant at the throttle bushing to shaft outside diameter.
5. Fill the tachometer seal bore with test oil from test stand. Fig. 511-16. If the fluid is drawn into the pump, replace the seal.

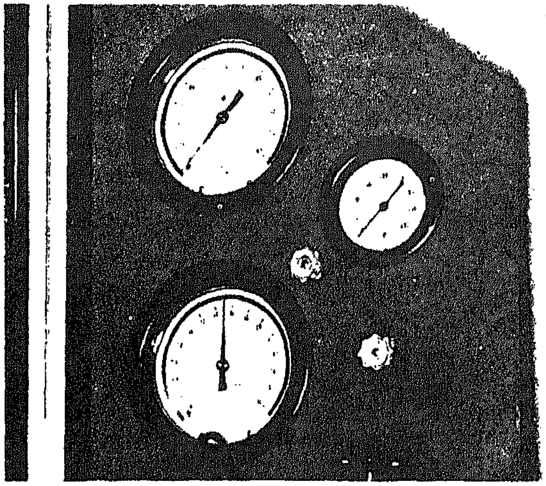


Fig. 511-14. Check vacuum gauge reading F5

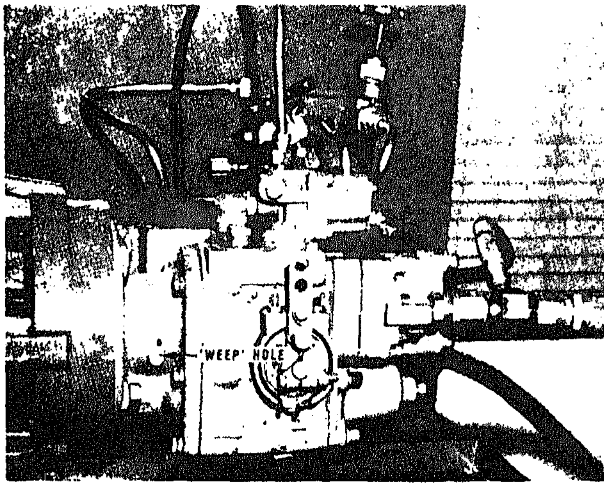


Fig. 511-15. Checking "weep" hole for leakage F5

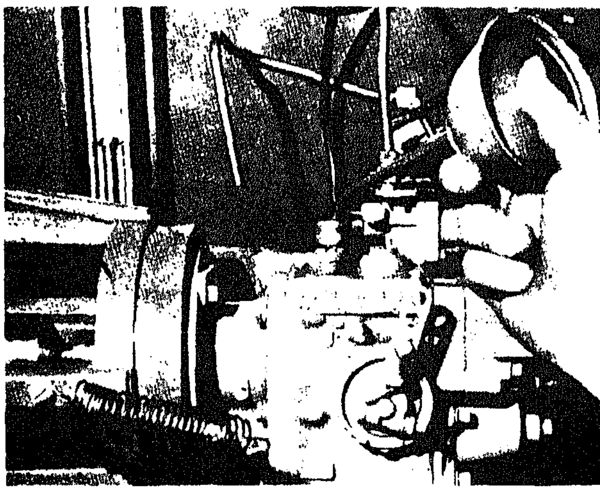


Fig. 511-16. Checking tachometer seal bore for leaks F

the fuel pump is equipped with an MVS or SVS governor, r leakage may occur at the speed control shaft or speed djusting screws. Adjusting screws and screw covers hould always be equipped with copper gaskets.

uring above checks, observe flow-meter for air in the eter which may or may not indicate air leakage into pump. ir may be entering lines between tank and pump. A slow ak may not show up promptly as air in the meter. Ob- erve fuel level in tank for possibility of low fuel causing r bubbles.

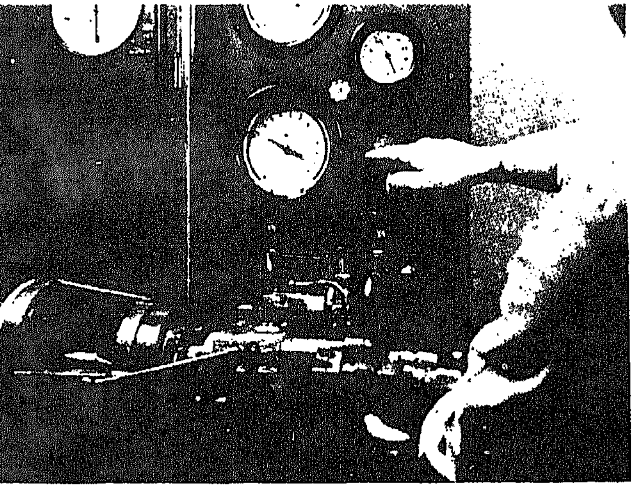
eakage may occur at the gear pump to pump housing gas- et if gear pump is not positioned correctly.

. Adjust Vacuum

pen test stand flow control or needle valve wide open.

crease pump speed to engine rated speed (2100 rpm on andard NH-220).

djust vacuum valve in fuel pump suction line to obtain 8" g. on vacuum gauge. Fig. 511-17.



g. 511-17. Adjust vacuum on suction restriction F5106

. Set Pump Flow

f the pump calibration data calls for over 800 pounds, per our flow on the flow-meter, you may have to replace the est stand manifold orifice with a S-1027 fitting, particularly n V12 pumps. If orifice is removed for calibration, be sure o reinstall for fuel pumps with lower flow rates or to cali- rate PT (type R) Fuel Pumps.

ncrease pump speed to engine rated speed as indicated n "Calibration Data" on following pages (2100 rpm on NH- 20).

Close the fuel manifold orifice or main flow control needle alve until the flow-meter shows the flow specified under Flow-Meter" in the calibration data (425#/hr. on an NH-220 ump). There must be nc air visible in the flow-meter. Fig.

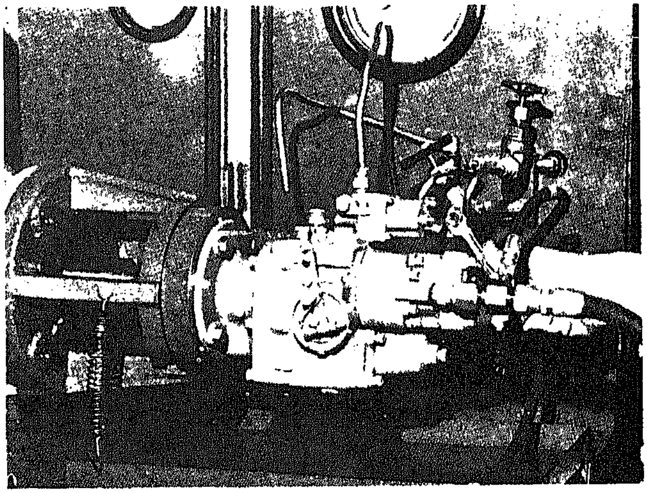


Fig. 511-18. Changing manifold orifice F5174

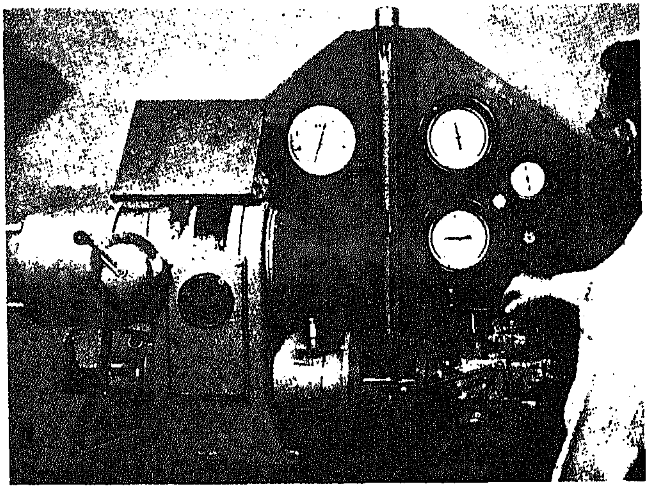


Fig. 511-19. Adjust manifold orifice valve for flow F5107

511-19. Disregard change in vacuum readings at this setting.

D. Set Governed Speed

1. With throttle in full fuel position, increase pump speed until point at which fuel pressure just begins to decrease (peak point). This should occur at speed indicated by "Governor Cut-Off RPM". For example: 2120/2140 rpm on NH-220 pump. Check speed with ST-774 by tripping twice as the fuel pump tachometer drive is turning at 1/2 engine speed. Fig. 511-20.

   Note: If MVS governor is mounted on fuel pump the maximum speed screw (top screw) must be backed out enough to let the automotive governor control governor cut-off speed and the MVS lever must be held in maximum speed position.

2. If speed is lower than specified, add shims between gov-

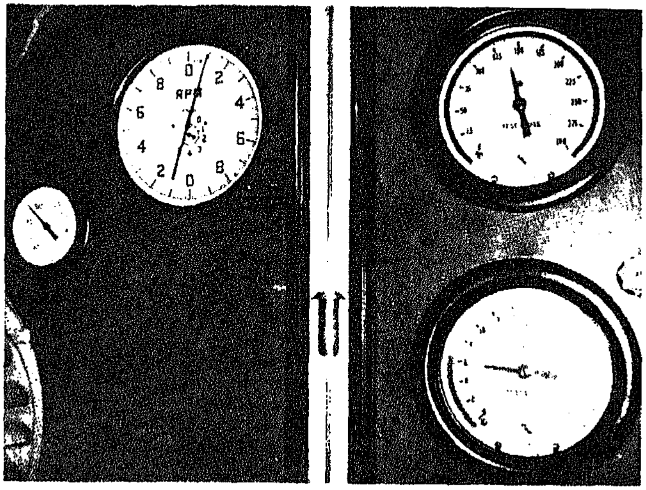


Fig. 511-20. Check governor cut off speed F5108

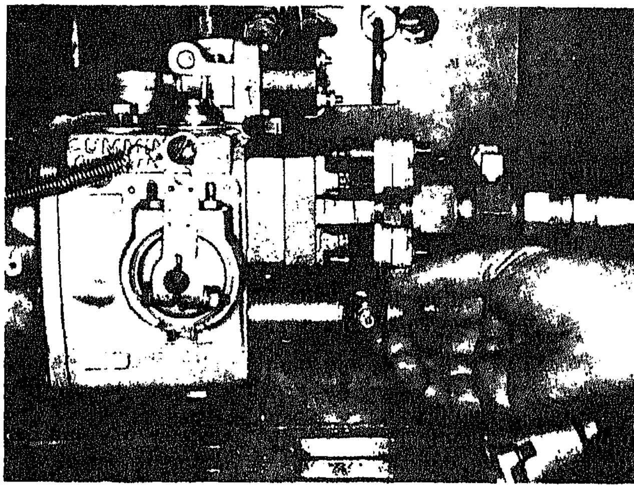


Fig. 511-21. Shim governor spring F5109

ernor spring and retainer. Check Table 511-2 for spring specifications. To reduce speed, remove shims. Each .001 inch shim thickness will change speed approximately 2 rpm. Fig. 511-21.

Table 511-2: Governor (Automotive or High Speed) Springs and Specifications

Part Number	Color Code	Replaces	Wire Diameter	Number Coils	Pounds Load @ Inches Length	Length
**143247	Yellow		.092	7.44	17.72/16.36 @ 1.00	1.487
143248	Yellow/Green	70711	.092	7.94	16.20/14.96 @ 1.00	1.487
143249	Yellow/White		.086	7.10	14.68/13.56 @ 1.00	1.487
143250	Red/White	70711A	.086	7.69	13.17/12.15 @ 1.00	1.487
**143251	Blue/Brown	70711B	.086	8.43	11.65/10.75 @ 1.00	1.487
143252	Red		.080	7.64	10.13/9.35 @ 1.00	1.487
143253	Red/Yellow	70711C	.080	8.64	8.61/7.95 @ 1.00	1.487
143254	Red/Brown	135158	.072	7.46	7.09/6.55 @ 1.00	1.487
143255	Red/Green	*70711D	.072	8.99	5.57/5.14 @ 1.00	1.487
143256	White/Blue	70711E-F	.062	7.49	4.05/3.74 @ 1.00	1.487
**144478	White		.086	7.69	19.92/18.40 @ 1.00	1.737
**144479	Green		.086	8.43	17.63/16.27 @ 1.00	1.737
**144490	Orange		.080	7.64	4.93/4.55 @ 1.00	1.237
**144491	Light Blue		.080	8.64	4.19/3.87 @ 1.00	1.237
**147292	Brown		.092	7.00	16.02/14.78 @ 1.00	1.405
147293	Orange/Yellow		.092	6.65	13.72/12.68 @ 1.00	1.322
147294	White/Brown		.092	6.32	11.21/10.35 @ 1.00	1.245
147295	Orange/Red		.092	6.05	11.58/10.69 @ 1.00	1.237
147296	Brown/Green		.092	5.80	12.31/11.37 @ 1.00	1.237
153232	Blue		.086	7.10	6.60/7.14 @ 1.00	1.237
153235	Green/Orange		.080	8.64	6.40/5.90 @ 1.00	1.362
153236	Green/Blue		.086	7.69	9.78/9.04 @ 1.00	1.362
153237	Blue/Yellow	125498	.086	8.43	8.66/7.99 @ 1.00	1.362
153238	Blue/Red		.080	7.64	7.52/6.95 @ 1.00	1.362
157059	Blue/Orange		.092	6.32	20.75/22.03 @ 1.00	1.487
177629	Brown/Orange		.102	6.10	19.30/21.30 @ .945	1.270
70711-G	Orange/White		.054	5.50	1.82/2.07 @ 1.187	
70711-H	Lt. Blue/Orange		.047	4.50	1.50/1.71 @ 1.187	
70711-J	Lt. Green/White		.047	5.00	1.21/1.39 @ 1.187	
70711-K	Orange/Lt. Green		.041	5.00	0.78/0.89 @ 1.187	

*Also 110888.

**Formerly color coded — 143247 Yellow/Black, 143251 Red/Black, 144478 Black/White, 144479 Black/Green, 144490 Black/Orange, 144491 Black/Blue and 147292 Black/Brown.

so air may be expelled more rapidly from system. After air is expelled, reset flow-meter flow as outlined in "Set Pump Flow".

With SVS governor adjust speed by means of high speed adjusting screw. Fig. 511-26.

With the MVS governor pumps (except those used with Woodward Governor) adjust automotive governor as described under Step 1 then make the following adjustments.

Operate the pump at full throttle to exactly rated speed. Turn maximum speed screw (top screw) of MVS governor in until fuel manifold pressure starts to drop.

From this point one turn out will be required to set the MVS governor slightly above the automotive governor.

Note: This adjustment will not change the governor check speed as the MVS governor setting is higher than the normal automotive governor setting.

With the MVS governor fuel pumps (used with Woodward Governor) set as on an automotive governor with MVS governor except for the following adjustments.

Set the automotive governor to "go dead" ("governor break" or "governor cut off") 40/60 rpm above rated speed. Adjust this as usual with shims behind the governor spring.

Operate pump at full throttle at exactly peak manifold pressure. Turn top screw on MVS governor in until manifold pressure starts to drop 1-2 psi. From this point one turn out will be required to set the MVS slightly above the automotive governor.

Note: The governor check speed, at a given pressure (i. e. 40 psi), should be a maximum of 123/127% of rated speed if the rated speed is 2,000 rpm or below, and 113/117% maximum if the rated speed is above 2,000 rpm. The automotive

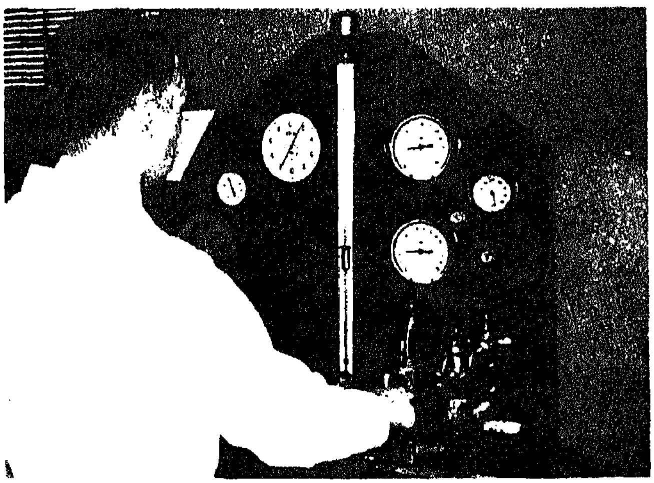


Fig. 511-22. Check governor speed at pressure F5110

3. Check governor setting by continuing to raise pump speed until fuel manifold pressure gauge drops off to 40 psi or as indicated by "Governor Setting — PSI — RPM" in the calibration data. Fig. 511-22.

4. At the pressure in Step 3, check tachometer speed; it should be within tolerances shown as rpm by "Governor Setting". For example: 2335 maximum on NH-220 pump.

   Note: If Step 1, "Cut-Off RPM", is correct, do not change speed in Step 4, this is a check point only indicating no-load speed, but if excessively high investigate for governor plunger wear or mal-function.

E. Set Throttle Leakage

1. Make throttle leakage setting on pumps with front throttle screw fully open.

   Note: Make sure fuel is hot when setting throttle leakage.

2. Move throttle all the way back toward gear pump and hold **firmly** against Stop.

3. Open leakage valve at end of orifice block wide open, close main-flow and idle valves.

4. Run test stand speed up to pump rated speed.

5. Place hose from valve at end of orifice block into 200 cc glass graduate. Check fuel delivery for one minute. Do not keep at this setting any longer than absolutely necessary. Fig. 511-23.

6. CC delivery should be as specified by "Throttle Leakage" in the calibration data. If not to specifications, screw front throttle stop screw in or out until cc delivery comes to specifications. This setting is extremely important as it affects the deceleration time of the engine. All pumps must be capable of attaining 15cc minimum leakage.

7. Check leakage with light and heavy lever load. If leakage is increased by additional pressure in the throttle closed

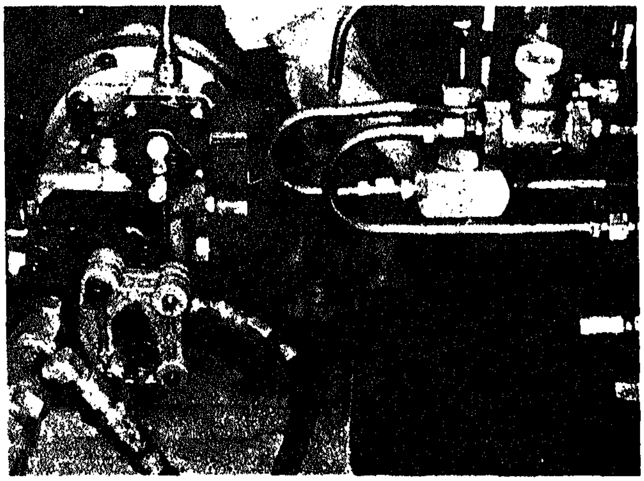


Fig. 511-23. Measure throttle leakage F5111

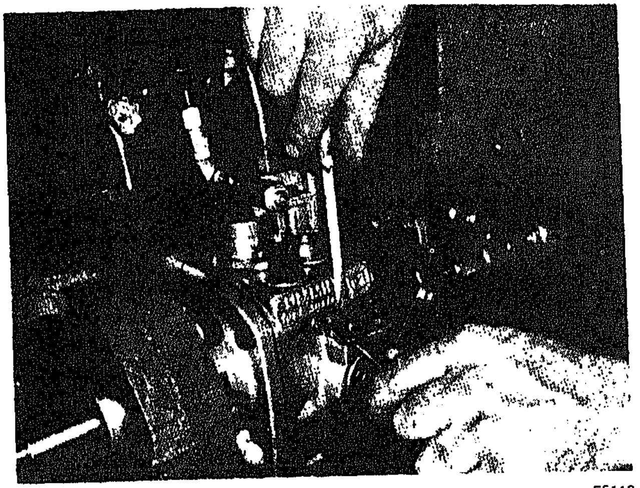


Fig. 511-24. Adjust throttle leakage rate F5112

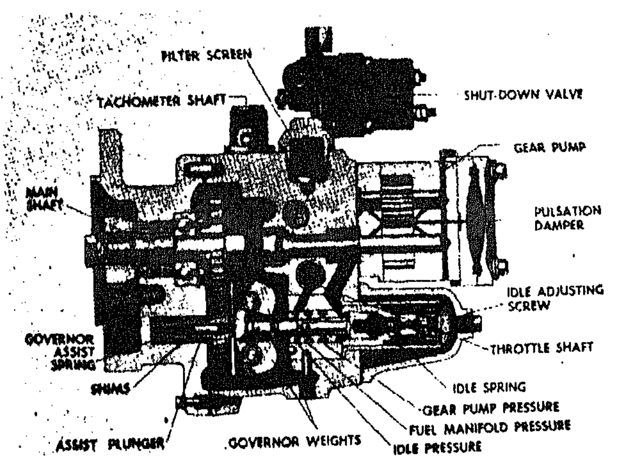


Fig. 511-25. PT (type G) fuel pump cross-section FWC5

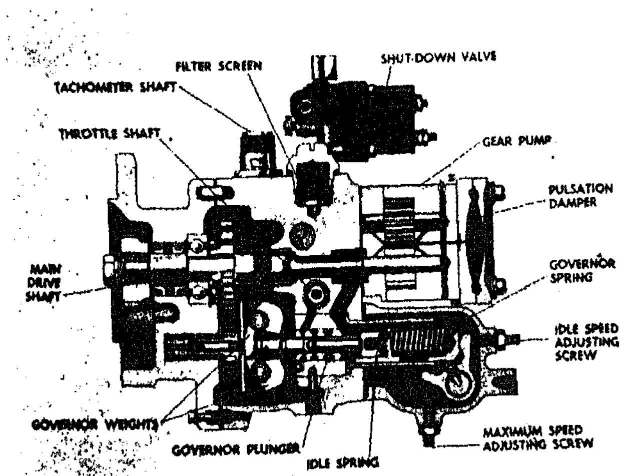


Fig. 511-26. PT (type G fuel pump with SVS governor FWC10

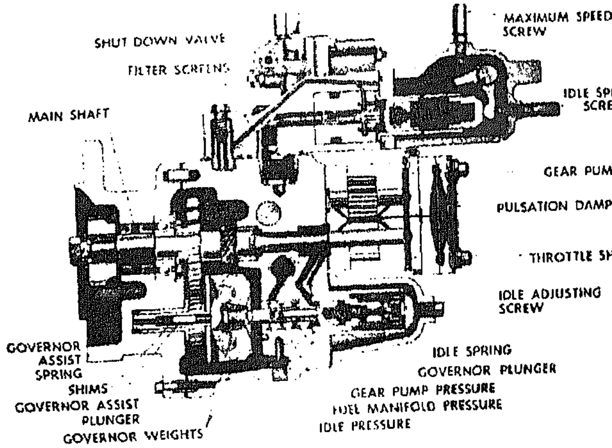


Fig. 511-27. PT (type G) fuel pump with MVS governor

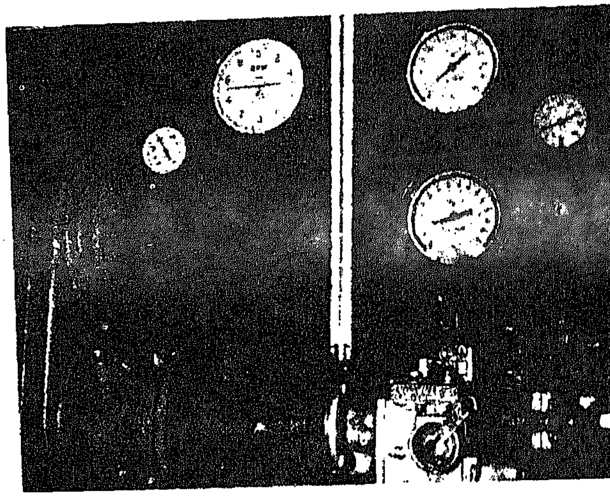


Fig. 511-28. Adjust fuel pressure at idle

position, set leakage under these conditions. If leaka
not be set to specifications, fit an oversize throttle s
the sleeve.

8. Lock screw when setting is correct and recheck.

F. Set Idle Speed

1. Close throttle leakage valve, close main flow contr and open idle orifice valve.
2. Set throttle shaft in idle position (all way back towa pump) and hold firmly against stop.
3. Run test stand up to speed indicated by "Idle Sp the calibration data. With SVS Governor the govern must be in high speed position and idle is adjusted ing or removing shims from the idle spring.
4. Check pressure on fuel manifold pressure gauge, i be as indicated by "Idle Speed". If pressure is lo

able 511-3: Torque Springs and Specifications

art umber	Color Code	Replaces	Wire Diameter	Number Coils	Pounds Load @ Inches Length	Free Length
8768	Red		.044	6.47	3.00/3.20 @ .340	.640/.660
8769	Blue		.044	5.72	3.60/3.84 @ .340	.640/.660
8780	Brown		.044	5.19	4.20/4.48 @ .340	.640/.660
8781	Yellow		.047	5.57	4.80/5.12 @ .340	.640/.660
8782	Red/Blue		.047	5.17	5.40/5.76 @ .340	.640/.660
8783	Red/Brown		.051	5.87	6.00/6.40 @ .340	.640/.660
878[illegible]	Red/Yellow		.051	5.52	6.60/7.04 @ .340	.640/.660
9584	Blue/Brown		.051	5.22	7.20/7.68 @ .340	.640/.660
9585	Blue/Yellow		.051	4.75	7.80/8.32 @ .340	.640/.660
9586	Brown/Yellow		.054	5.41	8.40/8.96 @ .340	.640/.660
8785	Red		.044	6.47	2.50/2.70 @ .340	.590/.610
8786	Blue		.044	5.72	3.00/3.24 @ .340	.590/.610
8787	Brown		.044	5.19	3.50/3.78 @ .340	.590/.610
8788	Yellow		.047	5.57	4.00/4.32 @ .340	.590/.610
8789	Red/Blue		.047	5.17	4.50/4.86 @ .340	.590/.610
8790	Red/Brown		.051	5.87	5.00/5.40 @ .340	.590/.610
8791	Red/Yellow		.051	5.52	5.50/5.94 @ .340	.590/.610
8792	Blue/Brown		.051	5.22	6.00/6.48 @ .340	.590/.610
9587	Blue/Yellow		.051	4.75	6.50/7.02 @ .340	.590/.610
9588	Brown/Yellow		.054	5.41	7.00/7.56 @ .340	.590/.610
8793	Red		.044	6.47	2.00/2.20 @ .340	.540/.560
8794	Blue		.044	5.72	2.40/2.64 @ .340	.540/.560
8795	Brown		.044	5.19	2.80/3.08 @ .340	.540/.560
8796	Yellow		.047	5.57	3.20/3.52 @ .340	.540/.560
8797	Red/Blue		.047	5.17	3.60/3.96 @ .340	.540/.560
[illegible]	Red/Brown		.051	5.87	4.00/4.40 @ .340	.540/.560
8799	Red/Yellow		.051	5.52	4.40/4.84 @ .340	.540/.560
8800	Blue/Brown		.051	5.22	4.80/5.28 @ .340	.540/.560
8801	Blue/Yellow		.051	4.75	5.20/5.72 @ .340	.540/.560
8802	Brown/Yellow		.054	5.41	5.60/6.16 @ .340	.540/.560
8803	Red		.044	6.47	1.50/1.70 @ .340	.490/.510
8804	Blue		.044	5.72	1.80/2.04 @ .340	.490/.510
8805	Brown		.044	5.19	2.10/2.38 @ .340	.490/.510
8993	Yellow		.047	5.57	2.40/2.72 @ .340	.490/.510
8994	Red/Blue		.047	5.17	2.70/3.06 @ .340	.490/.510
8995	Red/Brown		.051	5.87	3.00/3.40 @ .340	.490/.510
8996	Red/Yellow		.051	5.52	3.30/3.74 @ .340	.490/.510
8997	Blue/Brown		.051	5.22	3.60/4.08 @ .340	.490/.510
8998	Blue/Yellow		.051	4.75	3.90/4.42 @ .340	.490/.510
8999	Brown/Yellow		.054	5.41	4.20/4.76 @ .340	.490/.510
2698	White/Brown		.035	6.73	1.16/1.24 @ .350	.640/.660
2697	White/Yellow		.041	7.72	1.74/1.86 @ .350	.640/.660
2696	White/Blue		.041	6.29	2.32/2.48 @ .350	.640/.660
2701	White/Brown		.035	6.73	0.96/1.04 @ .350	.590/.610
2700	White/Yellow		.041	7.72	1.44/1.56 @ .350	.590/.610
2699	White/Blue		.041	6.29	1.92/2.08 @ .350	.590/.610
2704	White/Brown		.035	6.73	0.76/0.84 @ .350	.540/.560
2703	White/Yellow		.041	7.72	1.14/1.26 @ .350	.540/.560
2702	White/Blue		.041	6.29	1.52/1.68 @ .350	.540/.560
2707	White/Brown		.035	6.73	0.56/0.64 @ .350	.490/.510
2706	White/Yellow		.041	7.72	0.84/0.96 @ .350	.490/.510
2705	White/Blue		.041	6.29	1.12/1.28 @ .350	.490/.510
2843	White/Blue		.041	6.29	3.92/4.08 @ .350	.840/.860
2844	Red		.044	6.47	4.90/5.10 @ .350	.840/.860
2845	Blue		.047	6.76	5.88/6.12 @ .350	.840/.860
2846	Brown		.047	6.08	6.86/7.14 @ .350	.840/.860
2850	White/Blue		.041	6.29	3.52/3.68 @ .350	.790/.810

Table 511-3: Torque Springs and Specifications—Cont.					
Part Number	**Color Code**	**Wire Diameter**	**Number Coils**	**Pounds Load @ Inches Length**	**Free Length**
142851	Red	.044	6.47	4.40/4.60 @ .350	.790/.810
142852	Blue	.047	6.76	5.28/5.52 @ .350	.790/.810
142853	Brown	.047	6.08	6.16/6.44 @ .350	.790/.810
142854	Yellow	.047	5.57	7.04/7.36 @ .350	.790/.810
142855	Red/Blue	.051	6.30	7.92/8.28 @ .350	.790/.810
142857	White/Blue	.041	6.29	3.12/3.28 @ .350	.740/.760
142858	Red	.044	6.47	3.90/4.10 @ .350	.740/.760
142859	Blue	.047	6.76	4.68/4.92 @ .350	.740/.760
142860	Brown	.047	6.08	5.46/5.74 @ .350	.740/.760
142861	Yellow	.047	5.57	6.24/6.56 @ .350	.740/.760
142862	Red/Blue	.051	6.30	7.02/7.38 @ .350	.740/.760
142863	Red/Brown	.051	5.87	7.80/8.20 @ .350	.740/.760
142864	White/Blue	.041	6.29	2.72/2.88 @ .350	.690/.710
142865	Red	.044	5.47	3.40/3.60 @ .350	.690/.710
142866	Blue	.047	6.76	4.08/4.32 @ .350	.690/.710
142867	Brown	.047	6.08	4.76/5.04 @ .350	.690/.710
142868	Yellow	.047	5.57	5.44/5.76 @ .350	.690/.710
142869	Red/Blue	.051	6.30	6.12/6.48 @ .350	.690/.710
142870	Red/Brown	.051	5.87	6.80/7.20 @ .350	.690/.710

Table 511-4: MVS and SVS Governor Springs and Specifications					
Part Number	**Color Code**	**Wire Diameter**	**Number Coils**	**Pounds Load @ Inches Length**	**Free Length**
143849	Yellow (Idle)	.025	9	2.38/2.62 @ .325	.635/.665
153240	None (Idle)	.044	5.5	4.10/3.70 @ .295	.415/.445
109690	Pink	.080	8	18.5/15.1 @ 1.12	1.436/1.356
109689	Gray	.080	8.5	16.3/13.3 @ 1.12	1.424/1.344
109688	Brown	.080	9	14.1/11.5 @ 1.12	1.410/1.330
70822	Green	.080	9.5	12.65/10.25 @ 1.12	1.398/1.318
109687	Yellow	.080	10	11.2/9.2 @ 1.12	1.387/1.307
109686	Blue	.072	8.5	8.03/6.57 @ 1.12	1.358/1.278
70821	Red	.072	10	8.91/7.29 @ 1.12	1.435/1.355
107787	Yellow/Blue	.072	12.5	8.75/7.45 @ 1.12	1.522/1.442
101002	White	.063	11	6.43/5.47 @ 1.12	1.554/1.474
110461	Purple	.063	12.5	5.72/4.88 @ 1.12	1.568/1.488
110460	Orange	.063	14.5	4.97/4.23 @ 1.12	1.578/1.498
105422	Black	.054	11.5	3.35/2.85 @ 1.12	1.548/1.468
118128	Black/White	.054	14	2.42/2.84 @ 1.12	1.598/1.518

idle adjusting screw in; this screw is located inside governor spring pack housing. To lower pressure back out screw. For example: 10 psi at 500 rpm on NH-220 fuel pump.

Note: In rare cases it may be necessary to add extra washers on the spring end of the idle screw, if screw bottoms in guide and pressure is still low.

5. Setting MVS idle speed.

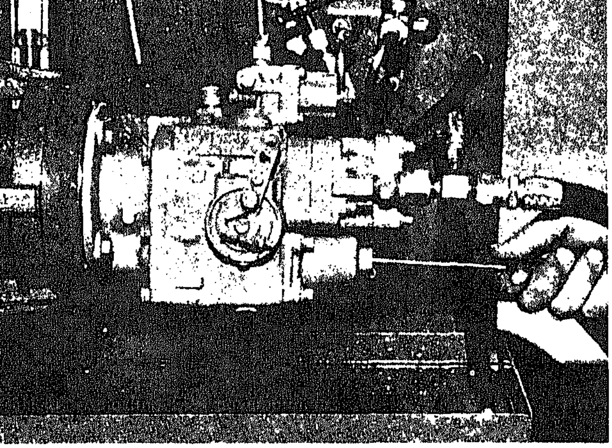
a. When setting idle on MVS governor pump (with restriction plunger in throttle shaft) set automotive governor as above then put throttle in full throttle position, move the MVS throttle to idle position and set at same idle speed as the automotive governor.

Note: Put slight finger pressure on MVS lever while se ting idle speed. Lock idle screw immediately after to pre vent air entrainment.

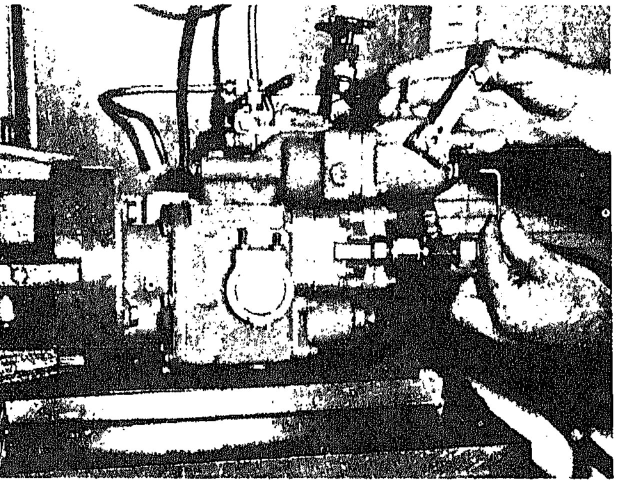
b. When setting idle on MVS governor pump with stu throttle shaft:

(1) Back out the automotive idle governor screw until it jus clears the retaining clip. This can easily be felt as th screw no longer has a positive resistance to rotation fro the spring clip.

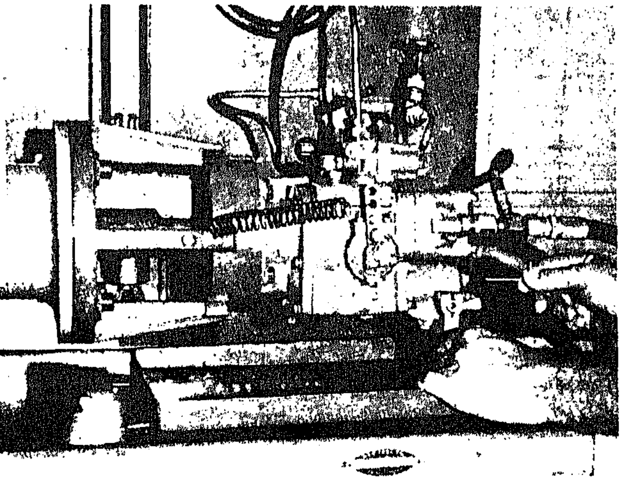
(2) Then set MVS lever in idle position and adjust rear MV screw until the idle pressure is 10-12 psi above the require



. 511-29. Adjusting automotive governor idle F5175



. 511-30. Adjusting MVS governor idle F5176



. 511-31. Adjusting SVS governor idle F5177

Code No.	Part No.	Counterbore Diameter
5	141623	.2085/.2115
7	141624	.2135/.2165
10	141625	.2185/.2215
12	141626	.2235/.2265
15	139894	.2285/.2315
17	140417	.2335/.2365
20	141629	.2385/.2415
22	141630	.2435/.2465
25	141631	.2485/.2515
27	141632	.2535/.2565
30	141633	.2585/.2615
32	141634	.2635/.2665
35	140922	.2685/.2715
37	140418	.2735/.2765
40	137370	.2785/.2815
42	140923	.2835/.2865
45	138862	.2885/.2915
47	140924	.2935/.2965
50	140925	.2985/.3015
52	139618	.3035/.3065
55	139619	.3085/.3115
57	140926	.3135/.3165
60	140927	.3185/.3215
62	141636	.3235/.3265
65	141637	.3285/.3315
67	141638	.3335/.3365
170	145947	.3385/.3415
172	145948	.3435/.3465
175	145949	.3485/.3515
177	145950	.3535/.3565
180	145951	.3585/.3615
182	145952	.3635/.3665
185	145953	.3685/.3715
187	145954	.3735/.3765
190	145955	.3785/.3815
192	145956	.3835/.3865
195	145957	.3885/.3915
197	145958	.3935/.3965
200	145959	.3985/.4015
202	145960	.4035/.4065
205	145961	.4085/.4115
207	145962	.4135/.4165
210	145963	.4185/.4215
212	145964	.4235/.4265
215	145965	.4285/.4315
217	145966	.4335/.4365
220	145967	.4385/.4415
222	145968	.4435/.4465
225	145969	.4485/.4515
227	145970	.4535/.4565
230	145971	.4585/.4615
232	145972	.4635/.4665
235	145973	.4685/.4715
237	145974	.4735/.4765

specifications, lock idle screw immediately after adjustment is made to prevent air entering system.

Note: Be sure to retain all the 1½ inch outside diameter shims between the governor barrel and the adapter plate. If any are lost, the following procedure must be followed; remove "O" ring seals from adapter plate and hold with spring pack housing installed in position against governor housing and barrel. Place enough shims against the barrel until there is .003 to .006 inch between the housing and adapter plate while held in position by hand pressure. Install "O" ring seal and reassemble.

(3) Adjust the automotive idle governor screw until the required idle pressure is obtained.

Note: The MVS idle adjustment pressure is decreased as the automotive idle screw is adjusted inwardly due to increasing gear pump pressure. This puts the governor in the most stable range of idle.

6. Run pump until purged of air each time pipe plug is removed to adjust idle screw, before rechecking pressure.

Note: If you have an early governor controlled fuel pump which has a starting groove in the governor plunger (3/64 wide) do not exceed 700 rpm idle setting on pump.

Close the idle orifice valve and open the main-flow valve.

G-1. Adjust Fuel Manifold Pressure With Internal Throttle Shaft Plunger

1. Place throttle in full fuel position. If MVS or SVS governor is used, the governor levers must be in maximum speed position.
2. Run test stand speed up to rated speed of pump as indicated by "Fuel Manifold Pressure" in the calibration data. For example: 2100 rpm on NH-220 pump.
3. Adjust fuel flow-meter to specified flow in calibration data. Check fuel pressure on fuel manifold pressure gauge.
4. To adjust pressure to specifications, stop test stand and remove the throttle shaft. Fig. 511-32.

   Note: All previous settings are made with the port fully open.
5. Remove shims from the restriction plunger inside the throttle shaft and replace assembly in fuel pump. Reset suction restriction valve to 5" Hg. after setting internal throttle restriction. Repeat pressure check and continue to remove or add shims until pressure indicated is 3 to 6 psi above "Fuel Manifold Pressure" value stated. For example: The chart shows 140 psi at 2100 rpm on the NH-220 fuel pump, therefore set the pump at 143/146 psi at 2100 rpm.

a. After each adjustment reset flow as specified in calibration data, while maintaining vacuum at 5" Hg.

b. If throttle shaft does not contain the restriction plunger, turn pump rear throttle screw until fuel manifold pressure and pump rpm is as indicated by "Fuel Manifold Pressure" in the calibration data. Lock throttle rear screw in place. An NH-220 pump at this point will show 140 psi at 2100 rpm at 425 #/hr.

c. On engines with hydraulic governors or other throttle lever travel requirements the fuel pump throttle shaft calibration Steps G-1 and G-2 are reversed as follows.

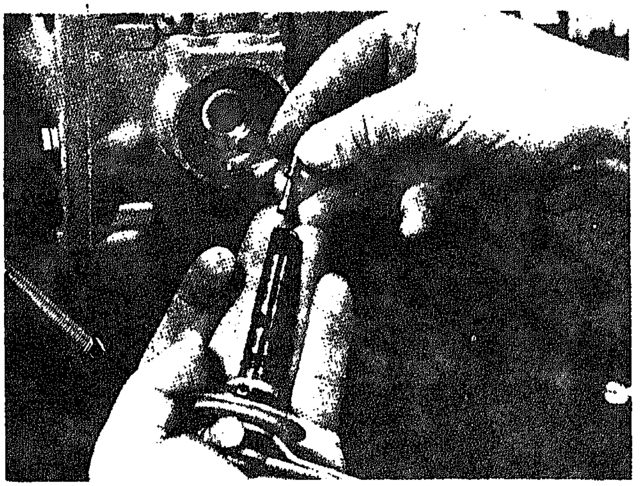


Fig. 511-32. Removing shims from restriction plunger F5114

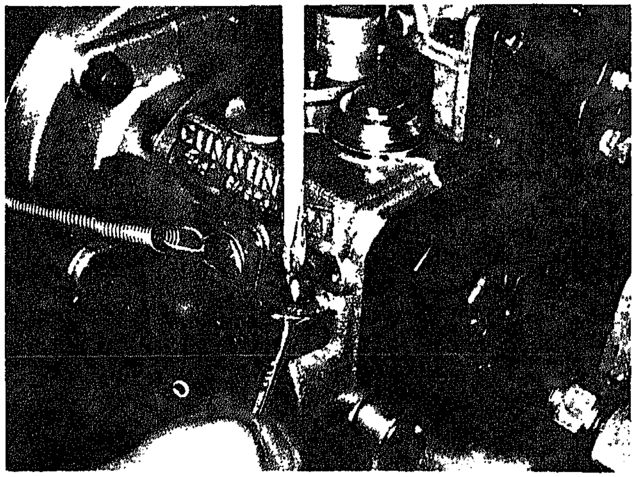


Fig. 511-33. Final fuel manifold pressure adjustment F5115

(1) Turn in rear throttle screw (Step G-2 on automotive fuel pump) until the required throttle lever travel is accomplished. Lock rear screw.

Note: Do not adjust front throttle stop screw to set throttle lever travel.

(2) Perform Step G-1 and adjust throttle shaft restriction plunger by shims until pressure indicated by "Fuel Manifold Pressure" is reached. Recheck.

G-2. Adjust Final Fuel Manifold Pressure With Rear Throttle Screw

1. After Step G-1, where throttle shaft contains the internal restriction plunger, with pump running at speed indicated by "Fuel Manifold Pressure", turn in rear throttle screw until fuel pressure is reduced to value indicated. Fig. 511-33. Lock screw in place. (At this point an NH-220 pump will show 140 psi at 2100 rpm at 425 #/hr.)

Steps G-1 and G-2 are both necessary to properly position the rear throttle screw where the throttle shaft contains the internal restriction plunger. For pumps without the plungers, see Step 5-B under Step G-1 only.

Recheck governed speed and pressures per Step "D".

For Marine SVS Governor applications lock automotive throttle in full open position at end of this adjustment, if used with overspeed stop.

H. Compare Check Point Pressures

Reduce speed to engine rated speed in calibration data. Check to make sure flow is set as specified (425 #/hr. at 2100 rpm on NH-220).

Reduce speed to that specified by "Check Point 1" in the calibration data. For example: 1600 rpm on NH-220 pump.

Check pressure at fuel manifold pressure gauge, "Check Point" pressure should be within the range indicated. For example: 108/114 on an NH-220 pump. Fig. 511-34.

If the pressure is above or below range, check the torque spring on the governor plunger; it may not be seated, improperly shimmed, or the wrong spring. See part number indicated in calibration data; if spring is changed, recalibrate fuel pump. Check weight assist protrusion or pressure to determine if it is influencing the check point pressure.

Reduce speed to that specified by "Check Point 2" in the calibration data. If out of specifications adjust weight assist but **maintain pressure indicated at 800 rpm under "Weight Assist" following.**

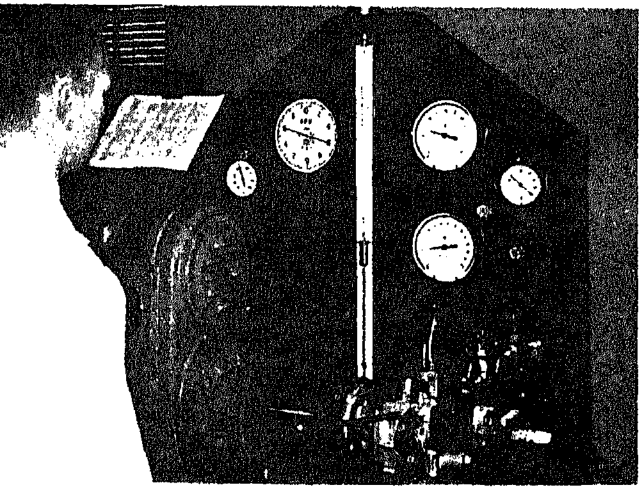


Fig. 511-34. Check point pressure readings F5116

I. Weight Assist Pressure Check

This check applies to fuel pumps with the governor weight assist plunger and is used as a check to make sure shimming is correct which will affect the engine low speed torque if not performed correctly. Fig. 511-35.

Decrease pump speed to 800 rpm.

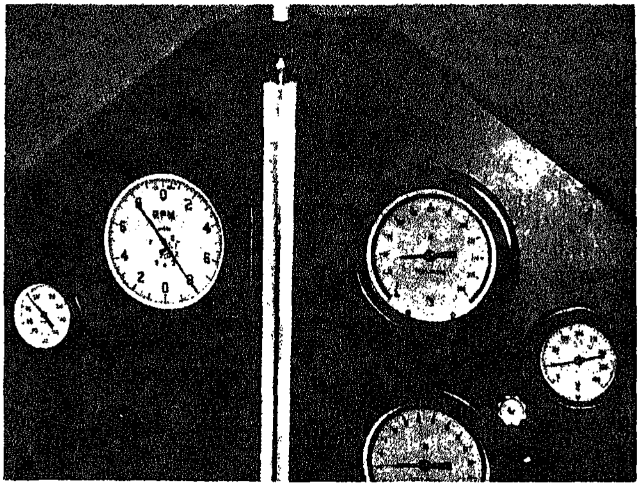


Fig. 511-35. Check weight assist effect F5117

2. The fuel manifold pressure should be as specified by "Weight Assist" in the calibration data. For example: 36/42 psi at 800 rpm on NH-220 fuel pump.

3. If fuel pressure is low, add shims below the governor weight assist plunger in the governor weight carrier. To decrease pressure remove shims. If shims are added or removed, recheck entire pump calibration.

Caution: Weight assist plunger must be installed with the smallest end to governor weights.

4. With SVS or MVS governors (used with power take off) raise fuel pump speed to the intermediate speed and move governor lever to low speed position and adjust low speed screw to obtain power take off speed, if required.

J. Cleaning Flowrators

Under normal operating conditions, a brown varnish like coating can build up on the inside of the fuel pump test stand flowrator. This coating can seriously affect the accuracy of the flowrator, plus make it difficult to read.

1. Remove complete flowrator from the fuel pump test stand. Do not remove tube from casing.
2. Mix 250cc of warm water and 25cc of 99045-84 cleaner.
3. Plug the top end of the flowrator and using a funnel, pour the cleaning mixture in the flowrator from the bottom end.
4. Gently tip the flowrator back and forth to agitate the liquid until the varnish like coating dissolves.
5. Pour out the cleaner and rinse once with warm water and once with fuel oil.
6. Assemble the flowrator to the test stand.

Recheck Specifications

1. When a PT (Type G) fuel pump is calibrated on one test stand and rechecked on another test stand, the calibration

values may vary. This can occur because test stands are not exactly alike, due to manufacturing tolerances, gauge tolerances, test oil viscosity variations, etc.

2. This variance can also occur when a pump is adjusted on the engine and then checked on a test stand.

3. The current Calibration Unit program is aimed at reducing test stand variations to an acceptable limit of ±2 PSI from a given base line by correcting gauging and plumbing errors and checking procedures.

4. A tolerance has been established on fuel pump calibration values for rechecking pump: (A) On another fuel pump test stand or; (B) On any fuel pump test stand after it has been calibrated on a test stand and then readjusted on engine. These tolerances are listed on the following pages.

5. If fuel pump is not within the tolerances listed under "B" above, one or more of the following is indicated.

a. Injectors are not properly calibrated and/or installed and/or adjusted.

b. Intake, exhaust or fuel suction restrictions are excessive.

c. Engine has incorrect components for the particular fuel pump calibration involved. (Injector cups, camshaft, pistons, etc.)

d. Pump was adjusted on engine to give other than specified fuel manifold pressure and fuel rate.

c. Test stand used for the recheck is not within acceptable limits.

Pump Specifications

1. GOVERNOR CUTOFF R.P.M. — Governor cutoff R.P.M. is defined as the RPM where the manifold pressure starts to decrease from the maximum observed pressure as speed is increased.

a. Recheck from one test stand to another; cutoff speed can vary ± 10 RPM from *published* cutoff point. (i.e.; 2520-2540 RPM cutoff speed, reflow can be 2510-2550 RPM).

b. Recheck from engine test to test stand; cutoff speed can be from rated speed to 50 RPM above rated speed. (i.e.; rated speed 2500 RPM, cutoff speed at reflow can be 2500-2550 RPM).

2. 40 PSI GOVERNOR CHECK POINT — The 40 PSI governor check point is obtained by increasing the pump speed beyond governor cutoff RPM until manifold pressure decreases to 40 PSI. Recheck from one test stand to another or from tested engine to test stand can be 10 RPM above the published speed. (i.e.; governor check speed 2685 RPM can be 2695 RPM at reflow).

3. THROTTLE LEAKAGE — Throttle leakage is set with throttle lever held firmly closed. The pump is operated at rated

4. IDLE SPEED MANIFOLD PRESSURE

a. Recheck from one test stand to another; manifold pres
can vary ± 10% from specifications or ± 1 PSI, which
is larger. (i.e.; 20 PSI @ 500 RPM can be 18-22 PSI a
check; 3 PSI @ 500 RPM can be 2-4 PSI at recheck).

b. Recheck after engine adjustment; manifold pressure
vary ± 30% from specifications. (i.e.; 20 PSI @ 500
can be 14-26 PSI at recheck).

5. MANIFOLD PRESSURE AT RATED SPEED

a. Recheck from one test stand to another; manifold pres
can vary ± 2 PSI from published specifications. (i.e.
PSI manifold pressure can be 124-128 PSI at reflow).

b. Recheck after engine adjustment; manifold pressure
vary same as on engine fuel pressure tolerance plu
additional ± 2 PSI. (i.e.; if engine pressure specificati
114-126 PSI or ± 6 PSI the tolerance for manifold pres
at recheck is (± 6) + (± 2) = ± 8 PSI. Then 126
manifold pressure can be 118-134 PSI at reflow).

6. MANIFOLD PRESSURE CHECK POINT — Recheck p
at rated speed and obtain exact manifold pressure per
ibration specification by adjusting flow control valve.

I. First check point can vary ± 1 PSI from published sp
cations. (i.e.; 100-106 PSI @ 2000 RPM can be 99-107
at reflow).

II. Second check to be as follows:

a. If pump checks + 1 PSI at first check point, it must
published minimum specifications to + 1 PSI above
lished maximum specifications at second check point.
75-81 PSI @ 1500 RPM can be 75-82 PSI at recheck).

b. If pump checks —1 PSI at first check point, it must
published maximum to —1 PSI below published mini
specifications at second check point. (i.e.; 75-81 PSI @
RPM can be 74-81 PSI at recheck).

c. If pump checks within the published tolerance at first c
point it must check within the published tolerance at
ond check point.

7. MANIFOLD PRESSURE AT WEIGHT ASSIST CH
POINT — Recheck of the manifold pressure at the w
assist check point can vary ± 1 PSI from the publ
specification. (i.e.; 35-41 PSI manifold pressure can be
PSI at reflow).

e 511-6: Calibration Recheck Specifications

ck	Recheck A—One test stand to another	Recheck B—Tested and readjusted on engine to fuel pump test stand
ernor Cut-Off I	±10 RPM from published values	Rated speed to 50 RPM above rated speed
ifold pressure le speed	±10% or ±1 PSI which ever is larger	±30% from published value
ifold pressure ted speed	±2 PSI from published value	Same variance as on engine manifold pressure tolerance plus an additional ±2 PSI
SI governor k point	+10 to —0 RPM from published value.	
ottle Leakage	±15cc from published value.	
t manifold ssure check t	±1 PSI from published values. Rated speed manifold pressure must first be to spec. by adjusting flow valve.	
ond manifold ssure check nt	A. If first check point is +1 PSI, second check point to be from published min. spec. to +1 PSI above published max. B. If first check point is —1 PSI, second check point to be from published max. spec. to —1 PSI below published min. C. If first check point is within published spec. second check point must be within published spec.	
ifold pressure /t. Assist ck point	±1 PSI from published value.	

el Pump Trouble Shooting With -775 or ST-848

s portion of the manual should be fully understood by Fuel Pump Test Stand Operator, and through this wledge he should be able to produce a properly calited Fuel Pump.

l Pump calibration on the ST-848 Fuel Pump Test Stand nbined with injector calibration has produced wideead acceptance of fuel system accuracy. There have been reports of erratic results, but investigations have revealed that the cause for such problems fall into three basic categories: (1) Mechanic and/or Testor Error, (2) Instrumentation Errors or (3) Maintenance Status.

1. Mechanic and/or Testor Error

a. Misapplication of specifications and parts:

(1) Calibrating a specific fuel pump model to the wrong value.

(2) Calibrating a specific injector model to the wrong flow value.

(3) Lack. of familiarity with this bulletin and/or Bulletin No.'s. 983505, 983533 or 983536.

(4) Use of camshaft and pistons other than those shown in fuel pump calibration specifications.

Note: Pistons, camshafts and injectors are sometimes superceded by others requiring a different calibration.

(5) Use of wrong injector assemblies in a specific engine model.

(6) Use of governor and torque springs other than those specified in fuel pump calibration data.

b. Engine Test

(1) Restricted intake air in engine.

(2) Excessive exhaust back pressure.

(3) Restricted fuel supply to engine.

(4) Aerated fuel supply to engine.

(5) Excessive high oil level in engine crankcase.

(6) Incorrect injector adjustment.

(7) Dirt entering balance orifice.

2. Instrumentation Errors

a. Erroneous fuel manifold pressure gauges on engine and/or chassis dynamometer.

b. Erroneous flow-meters.

c. Erroneous dynamometer load indicators.

d. Incorrect tachometer.

3. Neglect of Maintenance

a. Use of hose lengths, diameters and resiliencies other than those which are specified.

b. Fuel routing which is not to specifications.

c. Filter assemblies which have a different dampening effect on the system.

d. Critical components of the test stand such as check valve, gauge and hydraulic injector clamping poorly maintained.

e. Failure to make checks with master ST-768 gauge snubbers.

Complaint and Corrections

Charted on the following pages are the complaints, showing the items to check for correction of the complaints if the Fuel Pump Test Stand has been properly maintained leaving no Test Stand error. Each check is numbered may go immediately to the tabulated description causes and corrective action as necessary

No. 1 Complaint

Gear Pump will not pick up fuel at 450 RPM

- **Check 1** Openings Sealed
- **Check 2** Suction Connection
- **Check 3** Idle Plunger
- **Check 4** Governor Pl
- **Check 5** Passages Blocked
- **Check 6** Governor Assembly
- **Check 7** Pump Direction
- **Check 8** Flow Valv
- **Check 9** Shut-Down Valve
- **Check 10** Gear Pump
- **Check 11** Drive Coupling

Cause	Correction
Check 1: Openings not sealed correctly.	Seal all openings and use new gaskets where nece
Check 2: Suction connection is not tight or is damaged.	Tighten suction connection or replace if mutilated
Check 3: Idle Plunger dirty.	Check face of Idle Plunger (pressure control butt any foreign material.
Idle Plunger worn.	Change Idle Plunger to give a square fit with g plunger (use same Idle Plunger code number).
Check 4: Governor Plunger dirty.	Clean Idle Plunger mating face of foreign material
Governor Plunger worn.	Change Governor Plunger to give a square fit w Plunger.
Check 5: Blocked fuel passages.	Clean fuel passages so they are all open.
Check 6: Faulty governor assembly.	Check governor assembly for proper assembly.
Check 7: Pump turning wrong direction.	Check pump for right or left hand rotation and s stand accordingly.
Check 8: Flow valve not open.	Open test stand flow valve to allow fuel to enter gea
Check 9: Shut-down Valve not open.	Open shut-down valve on top of fuel pump
Check 10: Gear pump worn.	Replace gear pump if it will not deliver required flo
Check 11: Drive coupling not in mesh.	

No. 2 Complaint
Fuel will not clear in the main flowrator due to air leak

- Check 1 — Front Seal
- Check 2 — Suction Connection
- Check 3 — Shut-off Valve
- Check 4 — Tachometer Seals
- Check 5 — Fuel Level
- Check 6 — Throttle Shaft

Cause	Correction
Check 1: Front Seal leakage. This can be determined by covering "weep hole" in front cover with Lubriplate which stops air entrainment.	Remove fuel pump from test stand then remove front cover and install new seals in cover.
Check 2: Suction connection not tight or is damaged. This can be determined by pouring lube oil over suction connection.	Tighten suction connection or replace if mutilated.
Check 3: Shut-off Valve leaking air. Leakage past shut-off override shaft "O" ring or past main housing "O" rings.	Replace "O" rings which leak when lube oil is poured over shut-off valve "O" ring cavities.
Check 4: Tachometer drive seals leaking. Check by pouring lube oil over tachometer drive housing.	Remove fuel pump from test stand and disassemble pump enough to replace tachometer drive oil seal in main housing.
Check 5: Fuel level in test stand reservoir low.	Fill fuel reservoir with Cummins test oil.
Check 6: Throttle shaft "O" rings or housing leakage can be determined by pouring fuel oil over housing.	Replace "O" ring on throttle shaft or replace housing if leaking.

No. 3 Complaint
Governor cannot be adjusted correctly at breaking point

- Check 1 — Governor Spring
- Check 2 — Governor Weights
- Check 3 — Governor Plunger
- Check 4 — Governor Barrel
- Check 5 — Spring Pack
- Check 6 — Gasket

Cause	Correction
Check 1: Governor Spring incorrect due either to wear or incorrect Governor Spring.	Replace spring if worn beyond limits listed in Table 511-2.
Check 2: Loose or broken weights. Broken weight pins or carrier.	Replace with new parts as necessary.
Governor weights incorrect for that specific pump.	Governor weights should be installed of the correct weight (heavy or shaved).

Check 3: Governor plunger improper fit in governor Barrel.

Refit the governor plunger to the Barrel. This usually re quires a plunger one or two classes larger than previousl used and must be lapped to fit with No. 80 fine grit lappin compound. Remove all lapping compound after use.

Sheared governor plunger drive tangs.

Replace drive tangs on plunger assembly.

Check 4: Governor Barrel not located in housing correctly, preventing fuel passages from lining up.

Line up the fuel passages as not to restrict fuel flow. Thi may be done by heating housing in oven at 300 F. and re moving Barrel and then reinstalling in housing.

Governor barrel not pinned into position.

Make sure fuel passages are lined up and install pin int governor barrel.

Check 5: Spring pack lock ring out of position.

Lock ring must be in groove to correctly adjust governor.

Check 6: Gasket leakage between fuel pump housing and gear pump.

Gasket should be replaced or relocated. Correct gaske must be used.

No. 4 Complaint
40 PSI check point cannot be obtained within specified maximum speed limits

Check 1 Governor Plunger	Check 2 Governor Barrel	Check 3 Springs	Check 4 Weights

Cause

Check 1: Governor plunger has wrong chamfer or has worn chamfer.

Check 2: Governor Barrel and plunger incorrect fit.

Check 3: Governor or Torque Springs incorrect.

Check 4: Governor weight incorrect or weight assist setting incorrect.

Correction

Replace plunger with correct chamfer if improper chamfer

Refit Governor Barrel to accept a plunger one or two classes larger.

Install correct spring if wrong spring was used in assembly. See calibration data.

Change weights, install correct weights. Make weight assist setting pertinent to engine being calibrated.

No. 5 Complaint
Throttle leakage is above specified limit in calibration data

Check 1 Throttle Shaft	Check 2 Governor Plunger	Check 3 MVS Plunger

Cause

Check 1: Throttle shaft scored or incorrect fit in throttle sleeve.

Correction

Install next size larger throttle shaft and lap to fit, if neces sary. Fit to bore must be free without sticking tendenc when rotating or moving in or out of bore by hand.

Check 2: Governor plunger incorrect fit in governor barrel. — Install next size larger and lap to fit, if necessary, with lapping compound. Fit to bore must be free without sticking tendency when rotating or moving in or out of the bore by hand.

Check 3: Leakage past MVS plunger if MVS is used. — Install next size larger plunger and lap to fit.

No. 6 Complaint
Fuel Manifold pressure out of Specifications

- Check 1 Pulsation Damper
- Check 2 Idle Plunger
- Check 3 Gear Pump
- Check 4 Throttle Restriction
- Check 5 Flow Rates
- Check 6 Throttle Screw
- Check 7 Governor Weight
- Check 8 Governor Plunger

Cause	Correction
Check 1: Low fuel manifold pressure.	Replace fractured pulsation damper diaphragm.
Check 2: Fuel manifold pressure too high or too low because of incorrect Idle Plunger (Button) or surface finish.	Replace Idle Plunger (Button) with correct plunger if incorrect plunger was used. Polish surface of plunger if rough, burrs or chipped areas are found on surface of plunger.
Check 3: Gear Pump fails to obtain delivery and pressure.	Replace gear pump if delivery and pressure cannot be obtained.
Check 4: Wrong throttle restriction.	Set throttle restriction to correct values.
Check 5: Test Stand set at wrong flow rate.	Set test stand at flow rate indicated in calibration data pertinent to fuel pump being calibrated.
Check 6: Throttle screw out of adjustment.	Adjust throttle screw.
Check 7: Governor Weight Carrier assembly incorrect or faulty.	Replace with correct new governor weight carrier assembly.
Check 8: Scored governor plunger.	Replace with new governor plunger and lap to fit.

No. 7 Complaint
Check point pressure if below or above specifications

- Check 1 Idle Plunger
- Check 2 800 RPM
- Check 3 Springs
- Check 4 Weight Assist
- Check 5 Governor Weights

Cause

Check 1: Idle plunger or governor plunger rough or has voids.

Check 2: 800 RPM Checkpoint.

Check 3: Incorrect torque or governor spring.

Check 4: Incorrect weight assist protrusion.

Check 5: Incorrect weights or worn weight carrier assembly.

Correction

Polish surface with oil stone or replace if necessar

Check 800 RPM checkpoint under Complaint No. sure it is within specifications before proceeding.

Remove front cover and check for proper torque o nor spring.

Make correct weight assist setting or replace fro assembly.

Replace with correct new weight carrier assembly.

No. 8 Complaint
800 RPM Checkpoint out of Specifications

Check 1 — **Pressure Low**

Check 2 — **Pressure High**

Cause

Check 1: Checkpoint pressure is too low.

Check 2: Checkpoint pressure is too high.

Correction

If weight assist protrusion is within specifications more shim may be added to assembly to obtain checkpoint pressure.

Remove weight assist shims as required to decrea sure. If no shims can be removed, install new weig assembly or front cover.

No. 9 Complaint
Throttle Travel Below or Above Limit

Check 1 — **Loose Shaft**

Check 2 — **Governor Plunger**

Cause

Check 1: Throttle shaft too loose.

Check 2: Governor plunger fit incorrect.

Note: Be sure to re-mark throttle or governor sleeve if different size shaft or plunger has been installed.

Correction

Remove and check fit in throttle sleeve.

Check fit of plunger and install correct size plun

PT Fuel Pump Group

dition of the engine, parasitic loads and accuracy of the instruments used. At no time should adjustments be made on a cold engine. The engine should be run before making adjustments until oil temperature reaches 165°F. and with the valves and injectors set according to specifications.

Adjustment On Engine

Pump Hook-Up

the fuel pump has been removed from engine for calibration, proper hook-up is necessary.

nstall fuel pump to accessory drive or to compressor with ew gasket and proper rubber buffer, nylon buffer or spline oupling and tighten securely.

lote: Use black rubber buffer (spider) for engines rated t or below 2800 rpm. Use white nylon above 2800 rpm.

quirt some clean lube oil into gear pump inlet hole. This ds gear pump fuel pick-up.

onnect the fuel pump copper line from the pump shut-off alve to the fuel manifold.

he throttle lever linkage should not be connected to the rottle lever, thus leaving the throttle free for pump adstments.

stall accurate tachometer to fuel pump tachometer drive aft connection or use ST-774 hand tachometer.

onnect the shut-off valve electrical connections properly, aving the manual control button in a closed position crewed out).

onnect pump cooling drain line to check valve on housg or to check valve on gear pump.

hecking and Adjusting The Fuel Pump n The Engine

efore making fuel system checks or adjustments on enne be sure the following rules are observed:

ngine is at operating temperature.

jectors are correct part number, functionally satisfactory, owed to specifications and properly adjusted in engine.

amshaft is as specified for engine and particular pump, libration and is in good condition.

4. Pistons in use are those specified for the particular pump calibration specifications.
5. Instrumentation (gauges and tachometers) must have high accuracy.

Caution: Do not alter pump settings to satisfy gauges and tachometers of unknown accuracy.

6. Vehicle throttle control linkage is adjusted so full throttle is obtained and when released throttle is stopped by front throttle adjusting screw (throttle leakage adjusting screw).

Note: Vehicle throttle control linkage should have a maximum throttle stop, so when fuel pump full throttle is obtained override pressure will not be on throttle shaft.

7. When fuel pump has been properly calibrated, very little adjustment should be required after installation on the engine except idle since this setting is dependent on parasitic loads. Fine adjustment of governor settings and fuel manifold pressure is permissible within the specified limits if justified by engine performance tests.

Governor Settings

Idle Speed

1. After fuel pump installation, engine must be operated a sufficient period of time to purge all air from the fuel system and to bring engine up to operating temperature (at least 165°F. oil temperature).

Note: Idle speed adjustment should never be made on a cold engine.

2. Remove pipe plug from spring pack cover.
3. The idle adjusting screw is held in position by a spring clip. Turn screw in to increase or out to decrease the speed. Use ST-984 to adjust idle speed while engine is running. This tool seals the spring pack housing, permitting an accurate adjustment.
4. Replace pipe plug when idle speed is correct.

5. On SVS and MVS governor fuel pumps the maximum and idle adjusting screws are located on governor cover.

a. To adjust idle loosen rear idle adjusting screw lock nut.

b. Screw adjusting screw in or out to get speed required.

c. Tighten adjusting screw lock nut immediately after adjustment to prevent air entrainment.

6. Some problems with excessive vibrations have occurred at engine idle speeds particularly in truck applications that also have power takeoffs. This is particularly true of applications with cement mixers.

7. In these cases it has been found that a substantial amount of vibration can be eliminated by an adjustment of the engine idle speed to compensate for component cyclic vibrations present in each particular application. Table 511-7.

Table 511-7: Factory Recommended Idle Speeds

Engine Series	Idle Speed RPM
C	625 ± 20

8. These are recommended speeds and are intended as reference points. Judicious deviations can be made from these speeds although it should be noted that extreme care must be taken so that new problems are not created by extreme variations in idle speed.

9. Problems such as difficult gear engagement can be encountered with excessively high idle speeds. Poor load pick-up can be a problem if idle speeds are adjusted to low.

10. Excessively high governor weight assist settings have been found to be the cause of idle surge on C series engines having Part No. 168630 governor plunger (or oversizes).

11. Before concluding that the governor plunger is the cause of idle surge, check the weight assist protrusion against specifications.

High Speed

1. A means of loading the engine must be used to perform this check. The tachometer and fuel manifold pressure gauge must be of high accuracy. The engine fuel system must be purged of all air and at operating temperature.

'. The preferred method of checking governor setting is to "load" the engine on an engine or chassis dynamometer.

Maximum engine speed is adjusted by adding or removing shims under the high-speed governor spring. Normally, this adjustment is made on the fuel pump test stand as the fuel pump is calibrated and does not need to be changed on the engine.

Cut Off Setting

1. At full throttle increase load until the speed is pulled dow to at least 100 rpm below engine rated speed, then decrease the load gradually while observing the fuel manifol pressure gauge. (The fuel manifold pressure will increas with decreasing load until the governor begins restrictin fuel and then the pressure will begin decreasing with de creasing load.)

2. Continue decreasing load until fuel manifold pressur reaches its peak and decreases 1 to 2 psi. This is the s called "governor goes dead", "governor break" or "gove nor cut off" point. This speed is between 20 to 40 rpr higher than engine rated speed to assure that governor i not restricting before rated speed. (Example on a 2100 rpr engine this speed should be 2120 to 2140 rpm.)

3. If the governor cut off point is higher or lower than spec fications, shims should be removed or added from behin governor high speed spring accordingly.

4. Recheck the governor cut off point adjustment.

Engine Hi-Idle or Maximum No-Load Speed

1. Operate engine to purge all air from fuel system and brin up to operating temperature.

2. With transmission in neutral or the clutch disengaged, ope throttle and hold fully open. Note the maximum engin speed. This speed will be 10 to 12% greater than the gove nor "cut off" speed, depending upon engine parasitic load (fans, pumps, etc.).

3. This check should not be used to check or make governo speed adjustments. This check is of secondary importanc and must be considered as such unless the no-load spee is significantly greater than specifications in which case th governor assembly should be examined for malfunction o improper parts.

Checking and Adjusting Fuel Manifold Pressure

Listed below are three methods of checking fuel manifol pressure. The engine must be at operating temperature an fuel system purged of all air.

1. The preferred method of checking engine manifold pres sure is to load engine on an engine or chassis dynamomete as follows.

a. Check governor cut off as detailed previously.

b. At full throttle increase load until engine is pulled down t rated speed (accurate tachometer must be used). Rea fuel manifold pressure. If engine fuel manifold pressure below minimum or above maximum specifications, make th following adjustments.

(1) Screw out maximum throttle opening stop screw and utilize throttle restriction that may be present.

Caution: Do not screw the screw out beyond maximum throttle opening point otherwise a dead throttle travel may occur.

(2) Remove throttle shaft and add fuel adjusting shims as required.

To Decrease Pressure

(1) Remove throttle shaft and remove shims as required.

Caution: Under no circumstances should engine manifold pressure be set above maximum specifications. Doing so will void engine warranty.

(2) It should not be necessary to adjust fuel manifold pressure on a newly calibrated pump more than ±2 psi. If adjustments greater than this are required, fuel pump test, injector test stand or engine problems may exist.

The next best method of checking maximum engine fuel manifold pressure is to note maximum pressure while accelerating at full throttle when going up thru the transmission ratios. With proper gauge snubbing, this method can be relatively accurate, especially if a heavy load is being pulled and engine acceleration in the higher gears is slow.

The least preferred method of checking maximum engine fuel manifold pressure is the so called "snap" pressure check method.

The "snap" method is not as reliable as method 1 and 2 because the pressure reading is of very short duration.

Gauge inertia and/or the degree of throttle manipulation also reduces the reliability of snap pressure readings.

To take snap pressure readings, attach the ST-435 pressure gauge at the shut down valve in the usual manner. Fig. 511-36.

Disconnect the vehicle throttle control linkage at the throttle lever. Move lever clockwise against stop.

Start engine and run engine speed up to 200 to 300 rpm above idle by opening throttle slightly, then snap throttle to fully open position and permit engine to accelerate to maximum speed while observing pressure gauge. Note momentary maximum pressure. Take this reading several times.

Notes:

(1) Due to its poor reliability and inherent inaccuracy this check should not be used to gauge fuel pump test stand calibration accuracy.

(2) On turbocharged engines having aneroid it is necessary that fuel routing thru the aneroid be blocked or removed when making snap pressure checks.

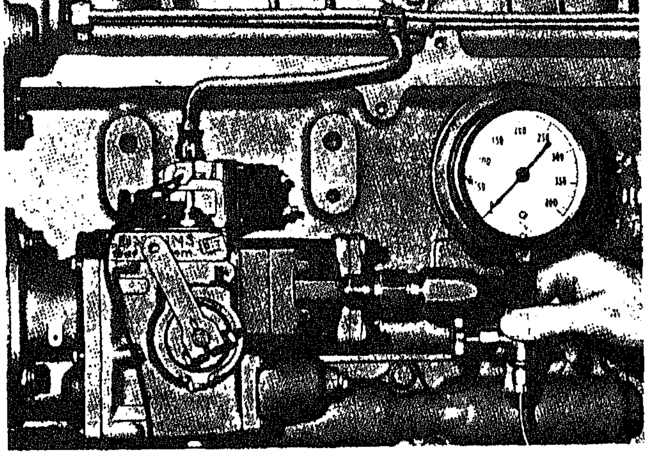


Fig. 511-36. Checking fuel manifold pressure F5178

Checking and Adjusting Engine Fuel Rate

Engine fuel rate (fuel consumption) in lbs. per hr. is measured by using ST-502 Flow Tank. Fig. 511-37, or a suitable means of weighing the fuel.

1. The fuel rate specified on fuel pump calibration specifications is at full throttle and rated speed.

2. An engine dynamometer, chassis dynamometer or other controlled means of loading engine must be used. Accurate fuel manifold pressure and speed readings must also be taken.

3. To check engine fuel rate, load engine at full throttle until engine speed is pulled down to and kept at rated speed (check governor cut off speed as described above while loading engine). Note fuel manifold pressure at rated speed. Hold engine speed and load stable at rated speed long enough for the flow meter float to stabilize. Take the fuel rate reading.

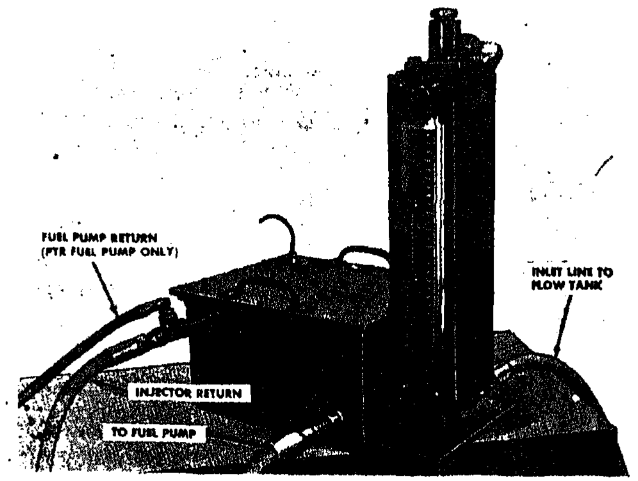


Fig. 511-37. Checking fuel rate F5179

4. If weight scales are used, hold load and fuel manifold pressure stable with full throttle at rated speed. With stop watch or other suitable timer, check number of pounds of fuel to be used in a five minute period of time (this can then be multiplied by twelve giving the lbs. per hr. fuel rate). Run several checks and average the readings, if they vary several lbs. Note full power smoke level for use in analyzing engine performance.

Throttle Leakage

1. The purpose of throttle leakage is to keep fuel lines or supply drillings and injector drillings full of fuel during closed throttle engine motoring.
2. Throttle leakage prevents engine response hesitation when throttle is opened after down grade closed throttle motoring and prevents the engine from stalling when it decelerates to idle.

a. Excessive throttle leakage will cause engine to decelerate too slowly.

b. Insufficient throttle leakage will cause engine response hesitation after closed throttle motoring and stalling after decelerating to idle.

Note: If throttle leakage is adjusted correctly on fuel pump test stand, adjustment after fuel pump installation on engine is not required.

3. If throttle leakage adjustment on engine is required, it should be performed in the following manner.
4. Engine must be operated long enough to purge all air from fuel system and at operating temperature.

Caution: Never check engine deceleration or adjust throttle leakage on a cold engine. Engine will decelerate faster when cold due to greater friction drag.

5. Vehicle throttle linkage must be adjusted so pump throttle just contacts the front throttle stop screw when throttle is closed.
6. A fuel manifold pressure gauge must not be in use.
7. A stop watch or other suitable timer and tachometer must be used to perform the following check.
8. With transmission in neutral or clutch disengaged, open throttle fully and let engine run at hi-idle (maximum no-load speed).

a. Release or move throttle to closed position quickly and start stop watch simultaneously.

b. Stop the stop watch when engine reaches 1000 rpm and note deceleration time. Repeat several times.

c. If engine begins to stall (idle governor does not catch engine) after decelerating from hi-idle, throttle leakage must be increased.

(2) Turn screw in while checking engine deceleration described previously until deceleration time is i creased 1 to 2 seconds. Lock screw in this position a recheck idle speed. Readjust as necessary.

9. If engine decelerates too slowly it may be necessary to d crease throttle leakage. Before decreasing throttle leaka be sure it is required by first checking deceleration ti when shut-down valve is closed (engine is shut down) wh running at hi-idle. If deceleration is no faster by this me od, throttle leakage is not the problem. If deceleration significantly faster by this method, throttle leakage sho be reduced.

a. Note position of throttle leakage adjusting screw.

b. Back screw out while checking engine deceleration described previously until engine tends to stall after d celerating from hi-idle. Turn screw in until decelerati time is increased 1 to 2 seconds. Lock screw in positi and check idle speed. Adjust idle speed as required.

Note: If a combination automotive and MVS governor pu is in use and there is excessive MVS governor barrel plunger leakage, this may be the source of high thro leakage and not the throttle shaft. This can be checked adjusting the MVS governor so engine will idle on the M (with automotive throttle fully open). With automoti throttle held fully open, accelerate and decelerate engi with MVS governor. If engine decelerates significantly fa er by this method than when the MVS is held in maxim speed position and engine is accelerated and decelera by the automotive throttle, there is excessive MVS gover barrel to plunger leakage.

Engine Power

1. Engine power can not be gauged accurately in any way cept on an engine dynamometer. Any other method of ga ing engine power requires the use of assumptions, f opinions regarding accessory drive train power losses load measuring equipment accuracy.
2. Fuel pump adjustments should not be made based on es mated power arrived at by this means unless full perfo ance data (fuel manifold pressure, fuel rate, speed settin smoke, coolant temperature, combustion smoothness, haust restriction, fuel quality, air intake restriction, cra case oil level and engine power derate factors) also in cates the adjustments are justified. Under no circumstan should these specifications be exceeded.

Note: As in all fuel systems and engine performa checks, accurate instruments must be used.

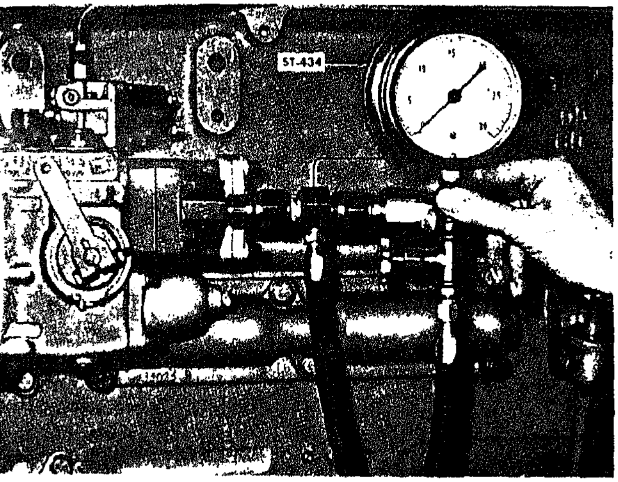
3. Engine rated power (maximum power at engine rated spe should be checked in the same way as "checking and justing engine fuel manifold pressure" and "checking adjusting engine fuel rate" as previously described.

:uel filter restriction can be checked using ST-434 Vacuum Gauge. Fig. 511-38.

Connect gauge using the special adapter furnished in ST-434.

f restriction reads 8 inch vacuum while engine is running at full speed and load, filter must be changed or other sources of restriction remedied. Sight glass gauge will show air bubbles with air entrainment and possible gasket or other leaks.

f air bubbles are persistent and the engine is over 400 brake horsepower, check the float valve assembly in the float tank (if so equipped). The gear pump may be pumping more fuel than the float valve will allow to pass into the float tank. A new interchangeable float valve is available with sufficient capacity to meet this requirement.



g. 511-38. Checking fuel restriction F5180

;eal Fuel Pump

o prevent unauthorized adjustments of the fuel pump after nal adjustments are made, seal the spring pack housing ower capscrews and the rear throttle screw or throttle over and spring pack cover plug.

pring Pack Housing Seal.

nstall bottom capscrew with drilled hole in head. Install lug with drilled hole into spring pack housing.

nsert seal wire through capscrew and plug.

wist the seal wire ends together until connection is secure and wire is tight.

Bend twisted wire into seal and press on top half of seal.

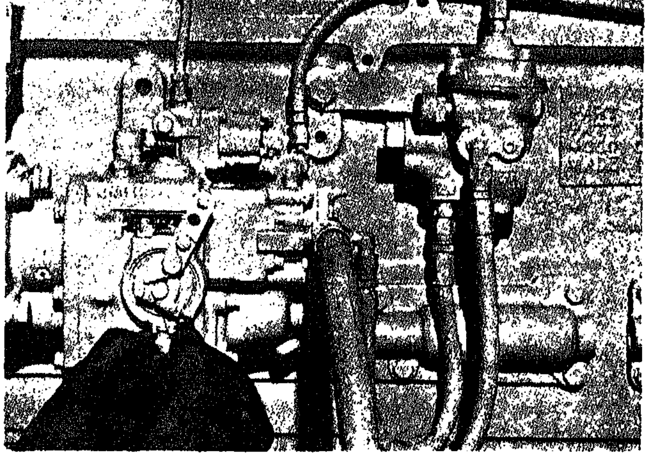


Fig. 511-39. Sealing fuel pump F5181

Precautions To Be Observed When Using Calibration Values On Following Pages

1. Refer to both lines of each pump calibration to get all values necessary for complete information.
2. Pump code numbers appear first; however, card number which appears on second line is equally important, and may mean there are differences necessary for special applications at the same horsepower, check "Remarks" at bottom of each page. Remarks for a particular calibration follow the card number.
3. A letter A, B, etc. following the card number indicates a minor change has been made from the original release and may be applied to all pumps with identical card number, regardless of the letter suffix. When a major change is made a new card is issued.
4. Governor and torque spring color codes are abbreviated (R for red, Bl for blue, etc.) to keep the values as compact as possible.
5. Due to changes in card number there may be more than one code, check complete page for given engine model to select correct calibration values.

CALIBRATION VALUES — TEST STANDS WITH FLOWMETER — PT (Type G) FUEL PUMP

ENGINE MODEL PUMP CODE	HP @ RPM	FUEL RATE LB. HR.	ENGINE FUEL PRESSURE	FLOW METER LB. HR. @ RPM	GOVERNOR CUTOFF RPM	GOV. SET PSI @ MAX. RPM	THROTTLE LEAKAGE — CC	IDLE SPEED PSI @ RPM	MANIFOLD PSI @ RPM	CHECK POINT 1 PSI @ RPM	CHECK POINT 2 PSI @ RPM	WEIGHT ASSIST PSI @ RPM	WEIGHT ASSIST SETTING	GEAR PUMP SIZE	IDLE PLUNGER CODE NO.	TORQUE SPRING PART NO. + SHIMS	TORQUE SPRING COLOR CODE	GOV. SPRING PART NO. COLOR CODE	GOV. WEIGHT PART NO.	INJECTOR PART NO. FLOW CODE	PISTON PART NO.	CAMSHAFT PART NO.
C-175																						
01SO 0952-C	175 @ 2500	69 72	155 175	620 @ 2500	2520 2540	40 @ 2735	35	12 @ 500	165 @ 2500	136-142 @2100	101-107 @1700	34-40 @ 800	.840 .860	3/4	30	139584 None	Bl-Br	143251 Bl-Br	163826	BM-71636 93	130500	121580
02SO 1026	162 @ 2200	63 67	140 160	575 @ 2200	2210 2230	40 @ 2450	35	38 @ 500	152 @ 2200	126-132 @ 1800	115-121 @ 1600	48-54 @ 800	.890 .910	3/4	27	138783 .020	R-Br	143253 R-Y	163826	BM-71636 93	130500	121580
03SO 0973	167 @ 2300	67	156 166	600 @ 2300	2310 2330	40 @ 2530	35	28 @ 500	156 @ 2300	133-139 @ 1900	Omit	40-46 @ 800	.870 .890	3/4	35	139584 None	Bl-Br	143253 R-Y	163826	BM-71636 93	130500	121580
03SO 1252	167 @ 2300	68	150 170	605 @ 2300	2310 2330	40 @ 2510	35	53 @ 500	165 @ 2300	140-146 @ 1900	127-133 @ 1700	45-51 @ 800	.900 .920	3/4	50	139584 None	Bl-Br	143250 R-W	146437	BM-71636 93	130500	121580
09SO 0962	175 @ 2800	73	172 182	615 @ 2800	2810 2830	40 @ 3120	35	23 @ 500	172 @ 2800	133-137 @ 2300	87-91 @ 1800	20-26 @ 800	.830 .850	3/4	50	139584 None	Bl-Br	143249 Y-W	163826	BM-71636 93	130500	121580
10SO 0964	160 @ 2800	68	135 155	590 @ 2800	2810 2830	40 @ 2990	35	23 @ 500	145 @ 2800	108-114 @ 2300	71-77 @ 1800	19-25 @ 800	.830 .850	3/4	180	139584 None	Bl-Br	143249 Y-W	163826	BM-71636 93	130500	121580
11SO 1023	122 @ 2200	49	83 93	410 @ 2200	2210 2230	40 @ 2390	35	28 @ 500	88 @ 2200	70-75 @ 1800	64-69 @ 1600	28-34 @ 800	.890 .910	3/4	55	138783 .020	R-Br	143253 R-Y	163826	BM-71636 93	130500	121580
12SO 1275	190 @ 2500			710 @ 2500	2510 2530	40 @ 2820	35	34 @ 500	210 @ 2500	159-165 @ 1900	142-148 @ 1700	45-51 @ 800	.920 .940	3/4	25	139584 None	Bl-Br	143251 Bl-Br	163826	BM-71636 93	130500	121580
13SO 1383	130 @ 2000	52	96 110	500 @ 2000	2010 2030	40 @ 2180	35	26 @ 500	110 @ 2000	89-95 @ 1600	82-88 @ 1400	44-50 @ 800	.890 .910	3/4	27	138784 +.020	R-Y	143254 R-Br	163826	BM-71636 93	130500	121580
04SO 1688	170 @ 2400	69		665 @ 2400	Omit	40 @ 2750	35	31 @ 500	170 @ 2400	Omit	Omit	35-41 @ 800	.830 .850	3/4	35	139584 None	Bl-Br	143251 Bl-Br	163826	BM-71636 93	130500	121580
14SO 1844	150@ 2500	61		590@ 2500	2520 2540	40@ 2700	35	2 @ 500	134@ 2500	111-117 @2100	87-93 @1700	31-37 @800	.900	3/4	45	139584 None	Bl-Br	143251 Bl-Br	163826	BM-71636 93	149200	121580
C-180																						
01TO 1574-C	180 @ 2500	76		690 @ 2500	2520 2540	40 @ 2750	150	43 @ 500	165 @ 2500	131-137 @ 1800	86-92 @ 1600	34-40 @ 800	.830 .850	3/4	45	138783 .080	R-Br	143249 Y-W	146437	BM-70821 93	130500	121580
01TO 1301	180 @ 2500	75 78	162 170	625 @ 2500	2510 2530	40 @ 2695	150	34 @ 500	160 @ 2500	115-121 @ 1800	96-102 @ 1600	28-34 @ 800	.830 .850	3/4	60	138783 .080	R-Br	143250 R-W	146437	BM-78021 93	130500	121580
02TO 0996	167 @ 2200	66	129 139	560 @ 2200	2210 2230	40 @ 2440	150	36 @ 500	134 @ 2200	103-109 @ 1700	88-94 @ 1500	30-36 @ 800	.830 .850	3/4	40	138783 None	R-Br	143251 Bl-Br	146437	BM-78021 93	130500	121580
05TO 0891	115 @ 2200	49	70 80	410 @ 2200	2210 2230	40 @ 2365	150	20 @ 500	70 @ 2200	49-53 @ 1600	Omit	13-18 @ 800	.830 .850	3/4	65	138783 None	R-Br	143252 R	146437	BM-78021 93	130500	121580
06TO 0937	176 @ 2400	75	150 160	595 @ 2400	2410 2430	40 @ 2710	150	28 @ 500	150 @ 2400	125-129 @ 2000	108-112 @ 1700	27-33 @ 800	.830 .850	3/4	55	138783 .080	R-Br	143250 R-W	146437	BM-78021 93	130500	121580
07TO 1080	145 @ 1800	60	110 130	520 @ 1800	1810 1830	40 @ 1910	150	70 @ 500	130 @ 1800	114-120 @ 1500	Omit	63-68 @ 800	.890 .910	3/4	22	138783 None	R-Br	143254 R-Br	146437	BM-78021 93	130500	121580
08TO 1120	125 @ 2400	53	80 100	425 @ 2400	2450 2480	40 @ 2650	150	24 @ 500	90 @ 2400	73-77 @ 2000	44-48 @ 1500	14-20 @ 800	.830 .850	3/4	190	138783 None	R-Br	143250 R-W	146437	BM-78021 93	130500	121580
11TO 1302	180 @ 2500	75 78	140 150	620 @ 2500	2510 2530	40 @ 2695	150	33 @ 500	148 @ 2500	107-113 @ 1800	86-92 @ 1600	27-33 @ 800	.830 .850	3/4	60	138783 .080	R-Br	143250 R-W	146437	BM-70195 104	130500	121580
12TO 1304	170 @ 2250	71	125 145	610 @ 2250	2260 2280	40 @ 2440	150	44 @ 500	142 @ 2250	117-123 @ 1800	99-105 @ 1600	31-37 @ 800	.830 .850	3/4	40	138783 None	R-Br	143251 Bl-Br	146437	BM-78021 93	130500	121580
13TO 1445	135 @ 2200	52 56	102 122	520 @ 2200	2210 2230	40 @ 2350	150	30 @ 500	112 @ 2200	79-85 @ 1600	60-66 @ 1400	26-32 @ 800	.830 .850	3/4	67	138783 None	R-Br	143251 Bl-Br	146437	BM-78021 93	130500	121580
14TO 1561	125@ 2400	49 53	83 103	425 @ 2400	2635 2665	40 @ 2760	150	19 @ 500	93 @ 2400	63-67 @ 1800	46-50 @ 1500	16-22 @ 800	.830 .850	3/4	190	138783 None	R-Br	143252 R	163826	BM-78021 93	130500	121580
15TO 1623	120 @ 2000	41 45	78 98	455 @ 2000	2020 2040	40 @ 2160	150	28 @ 500	88 @ 2000	70-74 @ 1600	61-65 @ 1400	28-34 @ 800	.830 .850	3/4	67	138783 None	R-Br	143252 R	146437	BM-78021 93	130500	121580
16TO 1649	120 @ 1500	41 45	82 102	500 @ 1500	Omit	40 @ 1825	150	63 @ 500	92 @ 1500	Omit	Omit	36-42 @ 800	.830 .850	3/4	30	None None	None	143252 R	146437	BM-78021 93	130500	121580
01TO 1664	180 @ 2500	76		660 @ 2500	2520 2540	40 @ 2710	35	36 @ 500	163 @ 2500	128-134 @ 2000	80-86 @ 1500	34-40 @ 800	.830 .850	3/4	52	138783 +.040	R-Br	143249 Y-W	146437	BM-78021 93	130500	121580
01TO 1681-B	180 @ 2500	76		645 @ 2500	2520 2540	40 @ 2730	150	45 @ 500	166 @ 2500	132-138 @ 2000	91-97 @ 1500	40-46 @ 800	.830 .850	3/4	50	139586 +.080	Br-Y	143250 R-W	146437	BM-78021 93	130500	121580
17TO 1745	125@ 220	52		460@ 2200	2220 2240	40@ 2350	150	25@ 500	90@ 2200	73-77 @1800	57-61 @1500	21-27 @800	.840	3/4	195	138783 None	R-Br	143251 Bl-Br	146437	BM-78021 93	130500	121580

PT Injector Group

Operating Principles—Unit 601

Injector Description

The PT Injector is a simple mechanical unit which receives fuel from the fuel pump under pressure and meters, injects and atomizes it through fine injector cup spray holes into the combustion chamber.

The general description "PT Injectors" is used only to indicate that the injector is used with the PT fuel system

The PT Injectors are cylindrical in shape without a flange for mounting.

Cylindrical PT (Type B) Injectors

Injector with a ball valve to aid in the control of fuel flow,

testing. The PT (type B) injector can easily be identif by socket head ball retainer plug at of injector body. Fig. 6-1-3.

The PT (type B) injector is used in engines with inter fuel drillings in the cylinder head and held in the head either a mounting yoke or mounting plates.

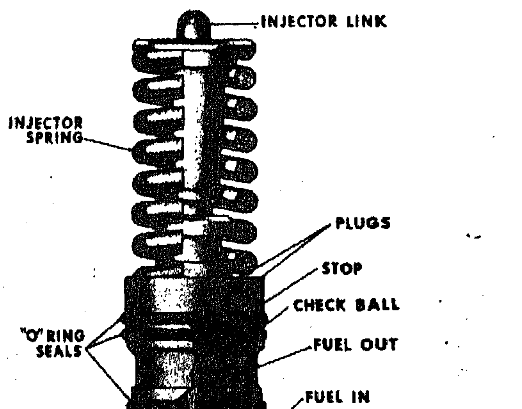


Fig. 6-1-8. Cylindrical PT (type B) injector cross-section FWC25

Injector Parts

Adjustable Orifice Plug

Orifice plug used in inlet drilling of flanged injectors and cylindrical injectors to adjust fuel delivery. Fuel delivery is adjusted by changing the orifice plug or by burnishing the plug in operating position, see injector description. Some orifice plugs have a flange and require a gasket beneath the flange.

Drain Orifice

The drilled orifice in cup end of the injector is the drain drilling. This orifice is fixed in size and must not be altered in any way.

Metering Orifice

The orifice in cup end of the injector allowing fuel to enter injector plunger bore and cup. This orifice is fixed in size and must not be altered in any way.

Cup Gasket

When PT fuel system injectors are fitted with oversize plungers, thicker cup gaskets must be used to provide the original relationship between the plunger and metering orifice.

Disassembly, Cleaning, Repair and Assembly

Disassembly

The disassembly, cleaning, inspection, repair and assembly procedures described on the following pages are those operations that may be performed in a clean, well equipped shop.

3. Remove "O" rings from injector body; discard rings.
4. Disassemble clamp securing screen to injector body remove button-style screen retainer ring, and remo screen.

   Note: *Do not remove adjustable orifice plug from in groove.*

Cylindrical Injectors

1. Lift out injector plunger and spring. Remove spring from plunger and then place plunger in body.

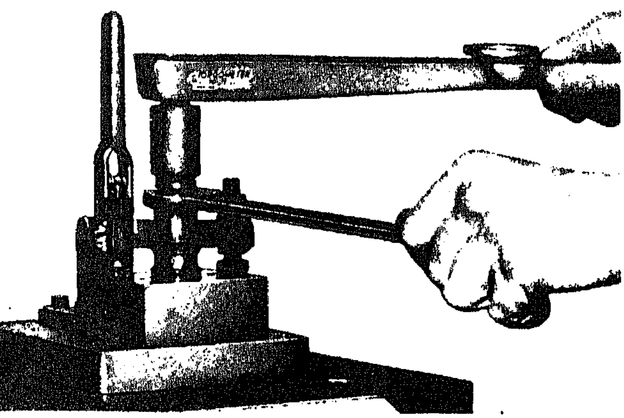
5. Place injector in ST-569-19 Adapter and install in ST- Holding Fixture so fixture spring tension is against injec plunger. Use spacers listed in Table 6-1-2 to get requi spring tension.

?emove injector cup using injector cup wrench ST934.

On cylindrical PT (type B) injectors, re-
nove ball retainer plug, gasket and ball from top of in-
ector body; discard gasket.

'able 6-1-2: ST-569 Spacer Data

njector Body 'art No.	ST-569 Spacer Detail(s) Required
31590	13 and 15



'ig. 6-1-7. Cylindrical injector in ST-569 holding fixture F60104

Cleaning

Clean injector parts thoroughly of any carbon or varnish by soaking in a solvent such as "Bendix Metal Cleane," 'Kelite Formula 1006" or equivalent.

Neutralize solvent after cleaning by dipping parts in mineral spirits.

3. Dry with clean compressed air.

   Caution: Do not use drills or other instruments to clean cup holes that will alter size of holes. Wires may be used if a smaller size wire is used than the spray hole.

4. A clean shop; clean tools and good cleaning practices are essential to good injector repair. Most injector failures occur because of dirt. Clean all parts before assembly.

Inspection

Injector Cup

1. Inspect injector spray holes and tip with magnifying glass. Compare with new cup shown in Fig. 6-1-8. Discard cup if any of following conditions exist.

a. Abrasive wear: This wear can begin internally; therefore, inspect both interior and exterior. Fig. 6-1-9.

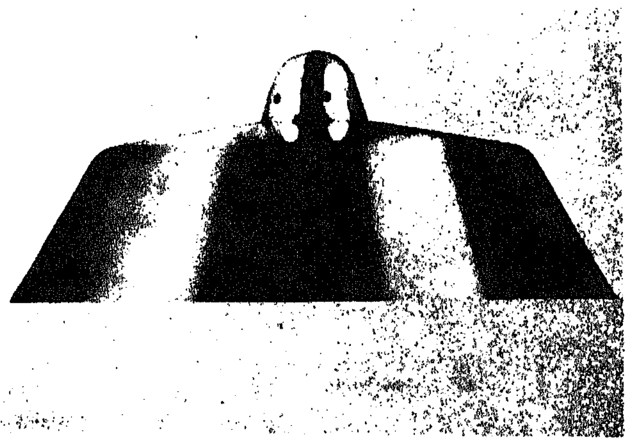


Fig. 6-1-8. New injector cup tip F60105

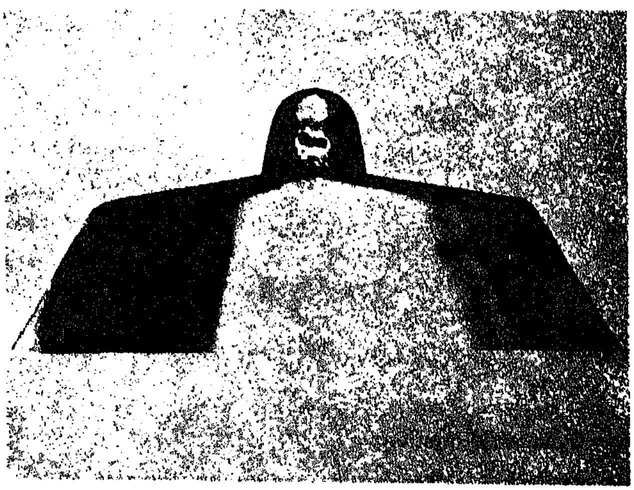


Fig. 6-1-9. Worn injector cup tip F60106

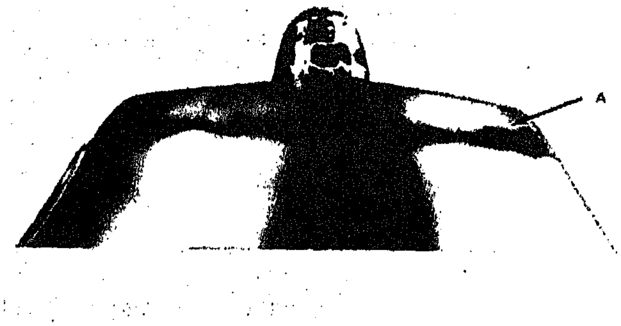


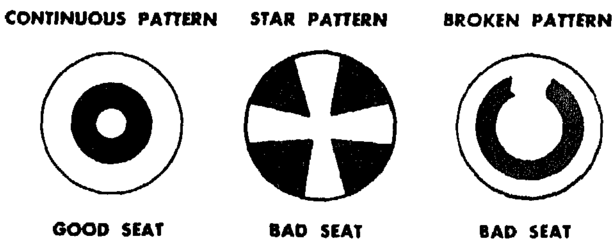
Fig. 6-1-10. Corroded injector cup tip F60107

b. Corrosion damage and effect of excessive heat: This condition usually results from high acid or sulphur content in fuel or overload operating conditions. Fig. 6-1-10.

c. Enlarged or distorted spray holes: Caused by cleaning with drills or other instruments.

2. Inspect cup for plunger seat pattern. If plunger seat covers 40 per cent continuous area around cup cone or plunger bore, it is possible cup may be reused, but it must pass the ST-990 cup to plunger leak test. Seat location is not important.

Caution: Never alter size of injector cup spray holes.



Injector Body

1. Inspect injector body plunger bore for scoring. If score are not too deep, injector body should be honed and fitted with a oversized plunger.

2. Use strong magnifying glass to check for burrs, carbo and distorted radii in orifices. When injector orifices ar damaged, the injector will not function properly. Do nc attempt cleaning with wires, plug gauges, etc; use solver cleaners.

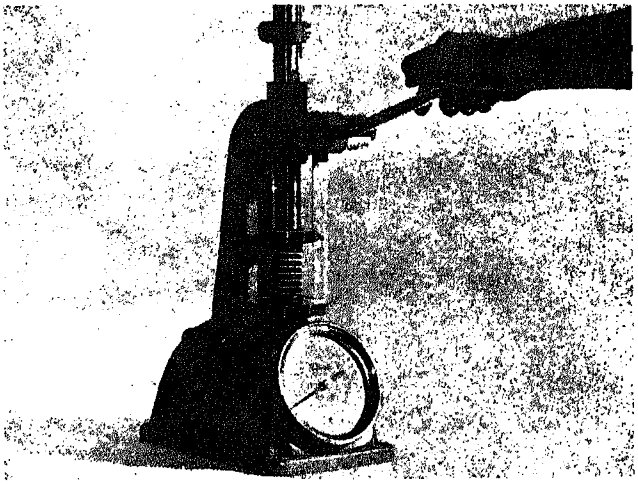


Fig. 6-1-14. Testing injector spring F60163

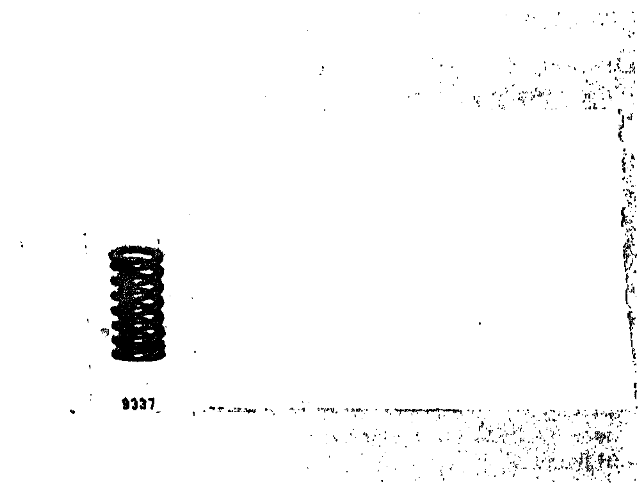


Fig. 6-1-15. Injector spring F60109

njector Plunger

Check closely for metal seizure. As a rule this is the only rue indication of scuffing or scoring.

Bright spots or surface disruption at top of plunger, on opposite side at bottom of plunger or at mid-point, usually are normal results of rocker lever thrust action. Unless metal is displaced or wear is measurable at these points, the plunger may be reused.

Narrow streaks running the length of the plunger usually are the result of the varying thickness of pentrate treatment used to prevent rusting and the plunger is satisfactory for reuse unless a surface disruption is evident.

Injector Spring

Check spring for excessive wear or mutilation.

Test spring tension on spring tester, Fig. 6-1-14, that is capable of very accurate measurements of spring lengths and applied load by means of standards and dial indicator gauge. Table 6-1-3.

If injector springs compress to dimensions shown, at less than load indicated under "worn limits", springs must be discarded. Fig. 6-1-15.

Repair

Replace Plunger Link

Replace plunger link if worn excessively. See Fig. 6-1-16.

2. Procedure to remove E ring type is as follows:

a. Place plunger in suitable holding device, such as block of soft wood, with spring retainer upward.

Table 6-1-3: Injector Spring Data

Part No.	Approximate Free Length Inches	No. Coils	Wire Dia. Inches	Pounds Load Required to Compress Springs to Length			
				Inch Length	New Min.	New Max.	Worn Limit
9337	$1\frac{7}{8}$	$8\frac{1}{2}$	.177	$1\frac{9}{16}$	135	149	130

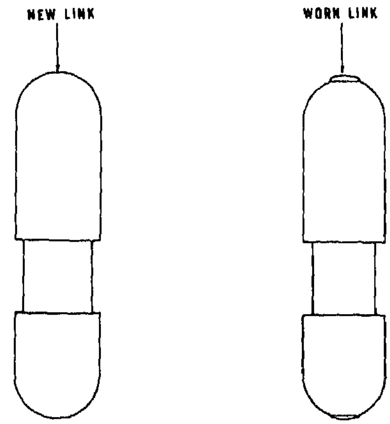


Fig. 6-1-16. Plunger link wear F60165

Fig. 6-1-17. Use tap holder to pull link F60110

b. Use a hammer and a punch with 1/16 inch point to break off "ears" of plunger link retaining ring. Remove link and remaining pieces of retaining ring.

3. A collet type hand tap holder, such as shown in Fig. 6-1-17, may be used to pull sleeve type injector links:

a. Place tap holder over link and tighten holder.

b. Hold plunger and give tap holder a quick pull.

Note: Do not put plunger in vise to pull link.

4. Place new retaining ring on new plunger link and press link into place. Fig. 6-1-18. If sleeve type retainer, press retainer flush to .010 inch below bore surface.

Caution: Handle injector plunger with care to prevent

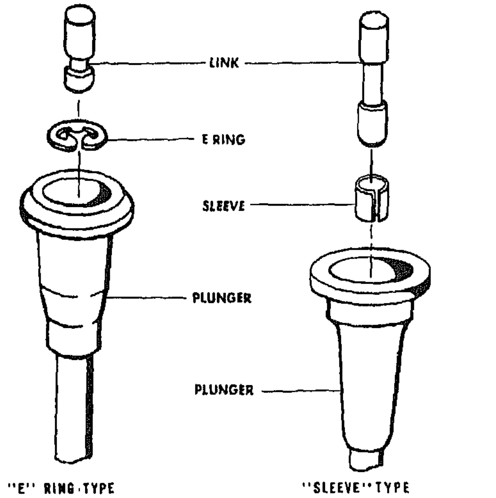


Fig. 6-1-18. Plunger link assemblies F6

Fig. 6-1-20. Intalling "O" ring with assembly tool F6011

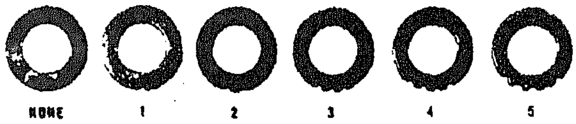


Fig. 6-1-21. Injector cup gasket markings F60113

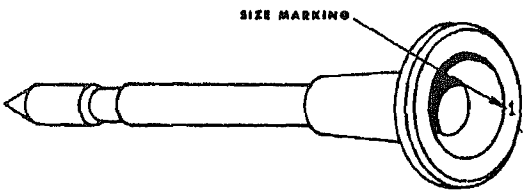
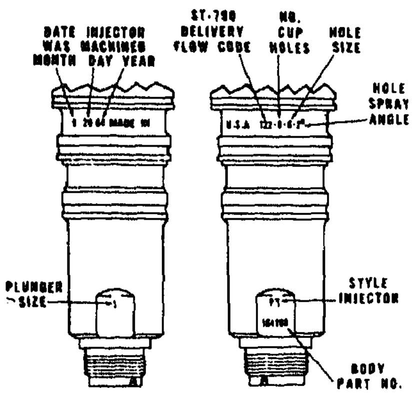


Fig. 6-1-22. Size marking location on plunger F60114



CYLINDRICAL

Fig. 6-1-23. Size markings on injector bodies F60115

405A

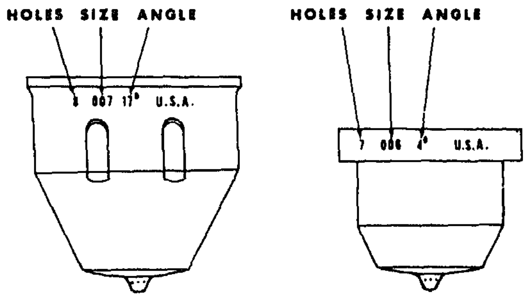


Fig. 6-1-24. Markings on injector cups F60116

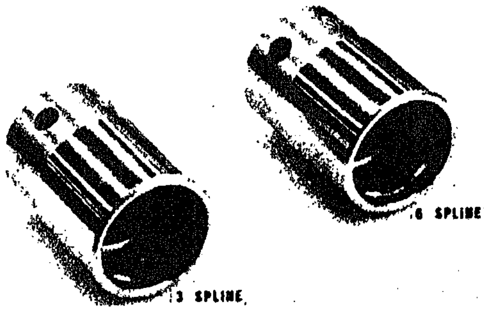


Fig. 6-1-25. Injector cup wrenches F60117

Injector Cup Gasket Data		
Cup Gasket Part No.	Gasket Notches	Body And Plunger Size Markings
62410	None	A, B, C, D, 0, 1, 2, 3, 4, 5, 6, 7, 8

Notes:

1. Unless proper gasket is used with corresponding body and plunger, the engine will develop a miss on cylinder containing the improperly rebuilt injector.

5. Check injector assembly plunger seating on ST-570 or ST-990, preferably ST-990 if available.
6. Remove injector plunger from body; lubricate plunger with test oil. Install injector spring and plunger in correct body; check to see that it does not bind as it seats in cup.
7. Check cup spray pattern as described on Page 6-1-18. If spray pattern tools are not available, fill injector body two-thirds full of clean fuel. Insert plunger forcing fuel out cup spray holes to see that they are open and clean.

Cylindrical Injectors

1. On PT (type B) drop check ball into bore at top of injector body. Install ball retainer with new gasket, and tighten to 50 inch-pounds maximum torque. Fig. 6-1-26. Refer to Page 6-1-18 for seating check, improper seating may result in "engine missing or slow shut-down" complaints.
2. Install new "O" ring with assembly tool ST426 each time cup is removed. Fig. 6-1-20.

a. Dip "O" ring in clean lubricating oil or liquid soap.

b. Assemble proper tool over threaded end of injector body.

c. Slide "O" ring over tool into groove.

3. Select new injector cup gasket corresponding to plunger body size. See Table 6-1-5 for cup gasket, Fig. 6-1-22 for location of size markings on plunger, and Fig. 6-1-23 for body markings.

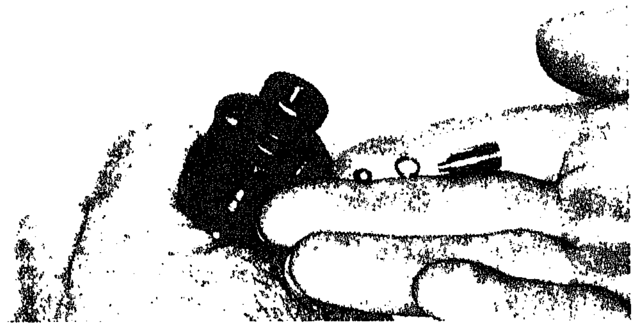


Fig. 6-1-26. Installing ball into injector body F60166

Notes:

a. When PT *injectors are fitted with oversize plungers*, thicker cup gaskets are used to provide the original relationship between plunger and metering orifice.

4. Immerse injector plunger in clean injector test oil and install in body without spring.
5. Place injector into ST-569 using ST-569-19 adapter and spacer. See Table 6-1-2 for correct spacer.
6. Apply tension to ST-569 Holding Fixture to align plunger in body.
7. Install proper cup down on injector body finger tight, then back cup up one-half turn.

Caution: Make sure all parts mating surfaces are clean and free from burrs or other imperfections which could result in incorrect flow.

8. Tighten cup to specified torque 45 ft-lb with cup wrench ST934 Spring tension in tool is controlled by spacers.

   Note: Two types of injector cup wrenches have been used, three spline and six spline, always use the six spline if possible. See Fig. 6-1-25.

9. Check injector assembly plunger seating on ST-570 or ST-990, preferably ST-990 if available.
10. Remove injector plunger from body; lubricate plunger with test oil. Install injector spring and plunger in correct body; check to see that it does not bind as it seats in cup.
11. Check cup spray pattern as described on Pages 6-1-18. If spray pattern tools are not available, fill injector body two thirds full of clean fuel. Insert plunger forcing fuel out cup spray holes to see that they are open and clean.
12. Lubricate and install outside (body) "O" rings into proper grooves.

_eakage Checks

'he plunger-to-body and plunger-to-cup leakage check ives a measurement of fuel by-pass between plunger body nd plunger cup to help determine if injector is to be re-oneu or can be calibrated and reused in an engine.

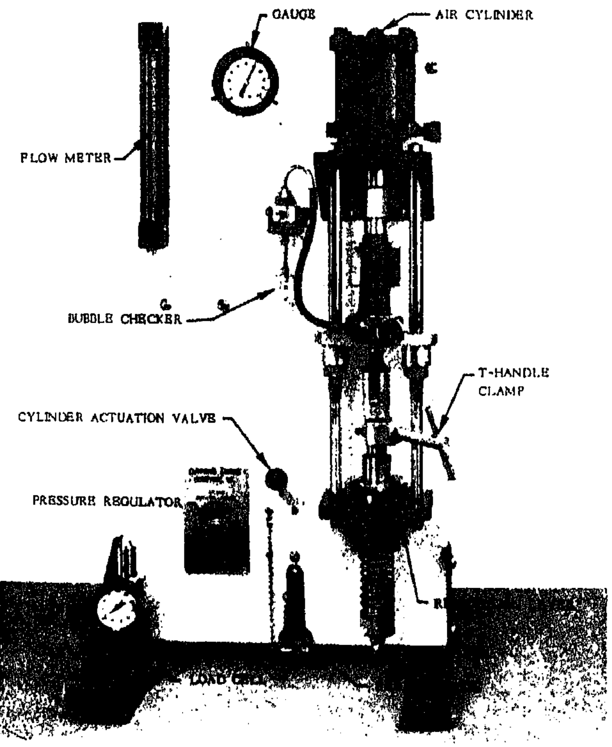
;T-990 Injector Leakage Tester

'he ST-990 Injector Leakage Tester was developed and re-eased in order to make available to the field a standard ool to accurately determine the degree of acceptability of sed injectors. Fig. 6-1-27.

'he ST-990 performs tests on all current Cummins PT in-ectors except L series. These tests are as follows.

3ody-to-plunger leakage in area below the metering ori-ce. With the plunger retracted off the cup seat by ap-roximately .048 inch, air is forced through the cup spray oles past the body-to-plunger clearance and is measured ith a precision flow meter.

his check supersedes the body-to-plunger leakage test on ST-790, in which injector delivery with a .055 inch re-trictor orifice is compared to delivery with the standard



g. 6-1-27. ST-990 injector leakage tester F60167

.011, .013 or .020 inch orifices (depending upon injector model).

2. Cup-to-plunger seat. The plunger is seated in the cup with 200 lbs. load. Any leakage is measured in bubbles which are released under a fluid level.

This check was incorporated into the ST-990 as a time and labor savings. Very little extra time is required to check the cup-to-plunger seat while the injector is installed in the machine for the body-to-plunger tests. This check is preferred over the ST-570 leakage check.

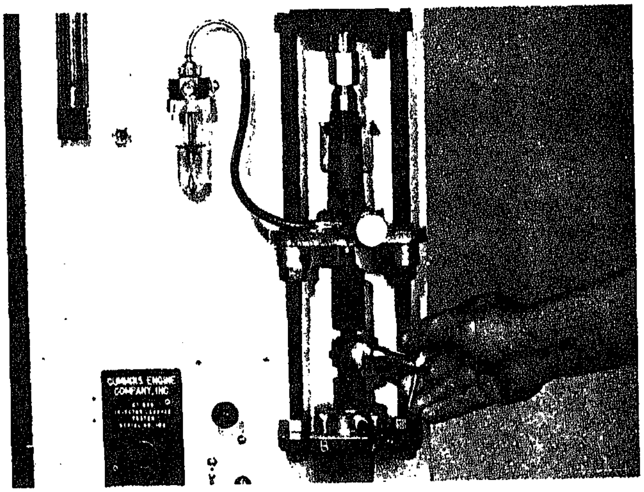
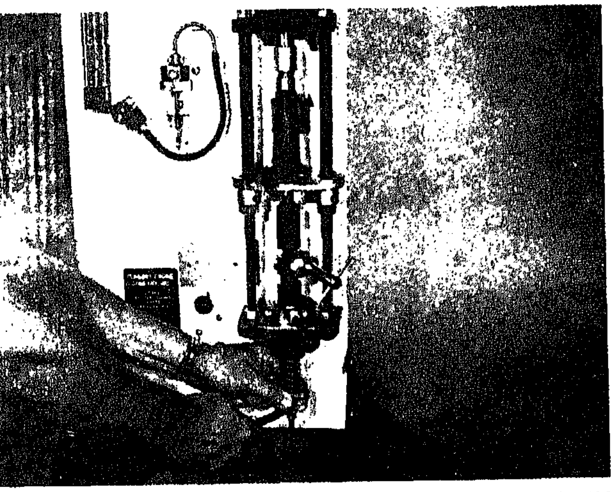


Fig. 6-1-34. Tightening T-handle clamp F60174



g. 6-1-33. Adjusting knurled hub for proper feeler gauge clearance F60173

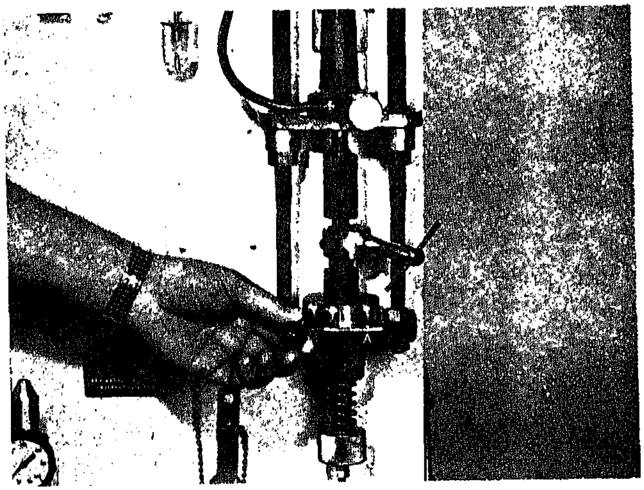


Fig. 6-1-35. Shifting retraction lever F60175

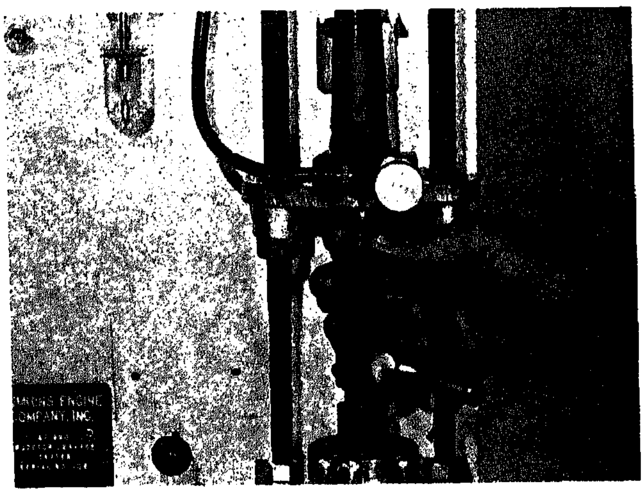


Fig. 6-1-36. Rotating plunger top F60176

Table 6-1-7: ST-990 Leakage Tester Data — Units Leakage		
Injector Model	**New**	**Used**
PT (Type B)	6.5	9.5

PT Cylindrical Injectors

1. Install ST-726 adapter to cylindrical injector. Fig. 6-1-37.

2. Plug fuel inlet port with ST-668-14.

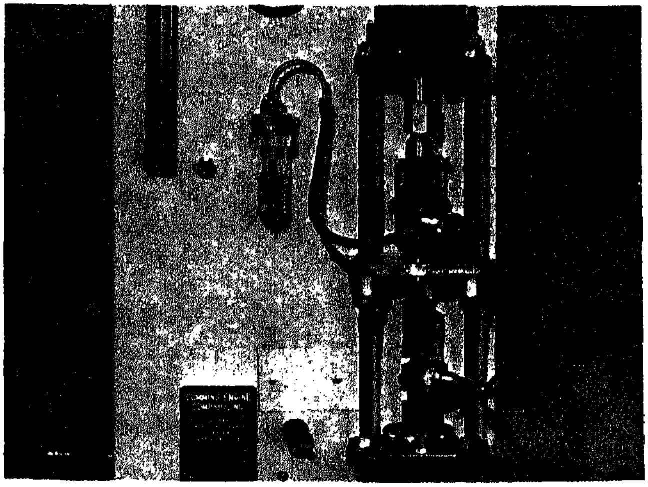


Fig. 6-1-37. Installing cylindrical injector in ST-990 F60177

3. Install injector into ST-990 and clamp into position. S
port plate may be tilted for easier installation of inject

4. Adjust knurled knob to obtain proper clearance with fe
gauge between knob and lock nuts. See Fig. 6-1-33.

5. Install and tighten transfer line in injector drain port. T
is the port on operator's right, facing front of test stan

6. Tighten T-handle clamp. See Fig. 6-1-34.

7. Shift retraction lever from "A" to "B" position. See
6-1-35. This removes load from plunger and allows it to
retracted from cup seat by approximately .048 inch. M
sure plunger retracts. The adherence of mating surfa
between plunger and cup sometimes holds plunger in
seat.

8. In this position presence of bubbles in bubble-checke
disregarded. Read air flow meter at top of ball float.

9. Rotate plunger top in clockwise direction by very small
crement and observe flow meter reading. See Fig. 6-1
Do not touch plunger top or any part of clamping me
anism while taking reading since external forces will
turb plunger from its normal position and may affect bo
to-plunger leakage on orifice area.

10. Continue to rotate plunger by small increments to
highest reading on flow meter.

11. Maximum readings on injectors which will satisfacto
perform throughout another service period are listed
Table 6-1-7.

12. If maximum leakage of injector being checked exce
specified values, injector must be sent to a rebuild sta
for replungering.

13. If maximum leakage does not exceed values listed in Ta

-1-7, shift retraction lever back to "A" position and loosen T-handle clamp. This applies 200 lbs. load to plunger.

The cup-to-plunger seal is acceptable if no bubbles occur in 10 seconds or if time interval between consecutive bubbles of air observed in bubble checker exceeds 5 seconds.

With checks completed and retraction lever in "A" position disconnect transfer line, exhaust the air cylinder and remove injector.

Alternate Method of Checking Plunger-To-Cup Leakage ST-570

ST-570 can be used to check injector plunger-to-cup seat (if ST-990 is not available) after completing injector assembly.

1. Attach ST-570 to an 80/90 psi air supply.
2. Remove spring and plunger from the assembled injector and reinstall plunger only in the injector body.
3. Place injector in ST-570 with cup seated in the counterbore below the air valve. Fig. 6-1-39.

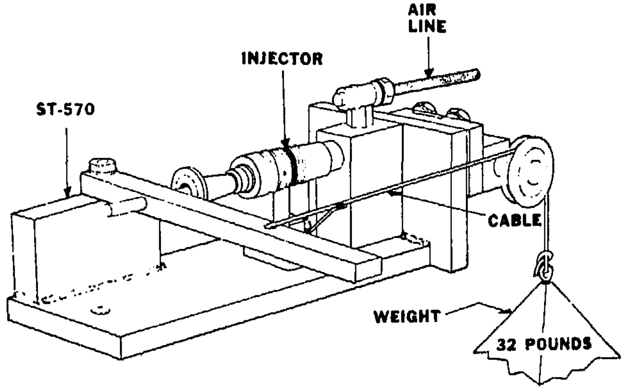


Fig. 6-1-39. Testing injector plunger-to-cup seating — ST-570 F60118

a. Position flanged injectors with inlet and drain holes up. Fill holes with fuel oil.

b. Install cylindrical injectors with drain and inlet holes up.

4. Position injector plunger.

a. With size mark centered between the injector inlet and drain openings.

b. Fill opening with fuel oil and operate plunger several times to purge any air trapped in injector.

5. Seat handle against injector plunger link and let the weight control the force against plunger. Do not apply any additional force to handle during test. Fig. 6-1-39.
6. Turn on air pressure (press air valve button). Injector is acceptable if the duration of time before the first air bubble appears is more than ten (10) seconds, and/or time between the observed air bubbles is not less than five (5) seconds.

   Caution: Before deciding the injector is leaking, be sure any air trapped in the fuel passages has been purged.

7. If leakage exists, check for dirt or other foreign material; changing or reassembly of the cup will often correct leakage.
8. Injectors are checked at the factory on the equivalent of the ST-990 for plunger-to-cup leakage.

The ST-570 is more critical on this test than the ST-990 and parts which appear defective on the ST-570 are acceptable if they pass the ST-990.

9. If the cup seat is damaged in any way and the injector does not pass the ST-990 or ST-570 cup-to-plunger seat test, the plunger may be lapped into the cup to obtain good seating. This lapping is to be done in a careful manner, without using the body. Use no greater than 300 grade lapping compound mixed with SAE 30 lubricating oil. Applying light pressure, oscillate the plunger in the cup back and forth for approximately one minute. Fig. 6-1-40. **After lapping, both the cup and plunger must be cleaned thoroughly, lapping compound will damage fuel system parts unless removed. The most effective cleaning process is the use of an "ultrasonic cleaner" and an after rinse in fuel oil.**

10. If injector is satisfactory, remove plunger; reinstall spring and plunger.

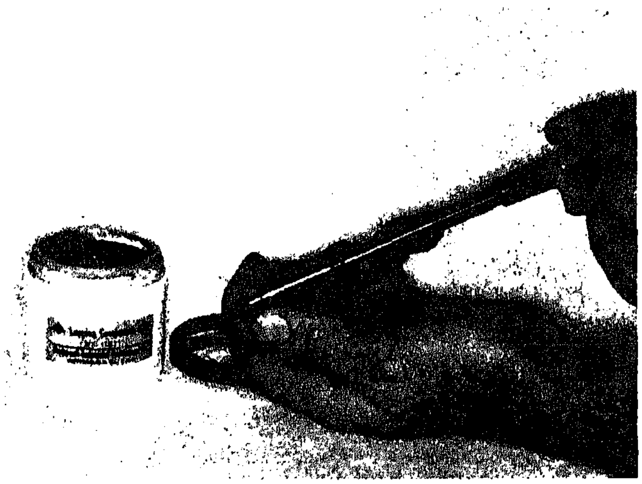


Fig. 6-1-40. Lapping injector plunger in cup F60179

Cup Spray Pattern Check

Check Injector Spray Pattern — ST-668

wo models of ST-668 are being used in the Field to check up spray pattern, the first was released in 1960 and con-ains black-oxide plated seat and seat spacers; the current ool contains "bright" cadium plated seat and seat spa-ers. The latter unit can be used with all Cummins in-ectors while the earlier model cannot be used with 2 de-ree spray angle injector cups.

you have ST-668 with black oxide finish seat and spacer, may be brought up-to-date by purchasing ST-668, Details 6, 2, 1, 17, 18, 19, 20, 22, 23, 24, 25, 4, 37 and 3 from your earest Cummins Distributor.

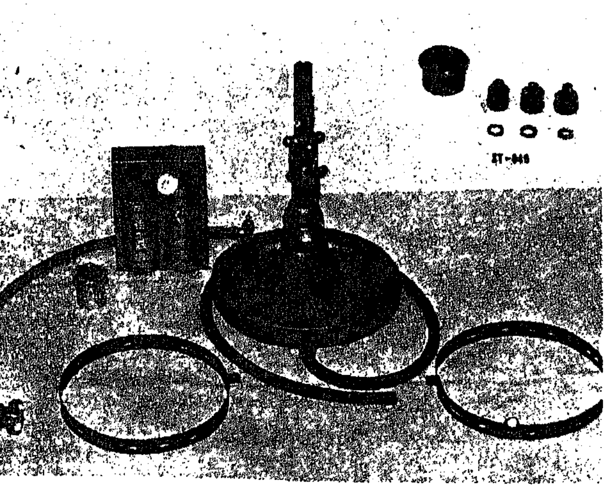
he following instructions are written with the understand-g that all ST-668 Spray Test Fixtures have been brought o-to-date.

ocate ST-668 on or near ST-790 Injector Test Stand, Fig. 1-41 (or other source of 50 psi constant fuel pressure) so jector inlet connection of test stand will reach injector be spray checked. Use injector test oil or fuel oil to erform test.

ttach drain hose to ST-668 base and place loose end in T-790 drain pan.

ssemble applicable cup seat spacer (see Table 6-1-8) to eat bracket bore.

ace "H-2" seat in seat spacer and bracket bore (seat racket bore only, if 2° cups are to be checked) or if L eries cups are to be checked use ST-849 (black) seat.



. 6-1-41. ST-668 spray test fixture F60119

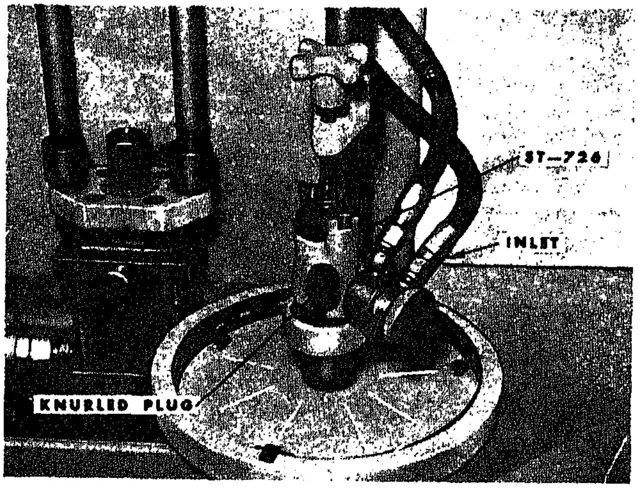


Fig. 6-1-42. Cylindrical injector in ST-668 F60120

Check cup markings as shown in Fig. 6-1-24 (7-007-17 indicates 7 holes, .007 inch diameter and 17° spray angle).

5. Check cup markings for number of spray holes and place applicable target ring in base of ST-668. Target rings are marked on the "handle" (6 and 9 holes or 5, 7 and 8 holes).
6. Insert cylindrical injectors in ST-726 Adapter. Fig. 6-1-42.
7. Remove plunger assembly and spring from injector.
8. Select correct size plunger bore plug and rubber seal and install in injector plunger bore. **Protect injector plunger from dirt or damage during tests.**
9. Install the solid knurled plug in injector drain opening, or in ST-726 Adapter, if cylindrical injector.
10. Place injector in ST-668 seat and adjust hold-down bracket into position required, then tighten thumb screw.
11. Tighten knob against plug and seal in plunger bore so it seals thoroughly.
12. Attach fuel inlet line from ST-790 or other pressure source to injector inlet or ST-726 adapter.
13. Start ST-790 Test Stand or other source of fuel and set pressure at 50 psi.

Table 6-1-8: ST-668 Cup Seat Spacers

Cup Spray Angle	Spacer Marking	Spacer Height	Use With Injectors
4°	J-4	0.187/0.193	C

14. Shift target ring in base of tool so one spray stream hits center of No. 1 or index window. This is tallest window and is next to target slide handle.
15. Each spray stream must hit a window in the target.
16. If a stream hits above, below, left or right of a small window, shift the target ring so No. 1 window is at that stream. If stream is still outside No. 1 window, cup is defective or spray hole is dirty. Clean spray holes with compressed air and recheck cup. If spray pattern is still defective, check to make sure proper target ring is being used, or discard cup.

    Note: For a cup to be acceptable no more than one stream must require the increased tolerance of the No. 1 window.
17. After testing, assemble plunger with spring in body and store in clean place until ready for flow test.

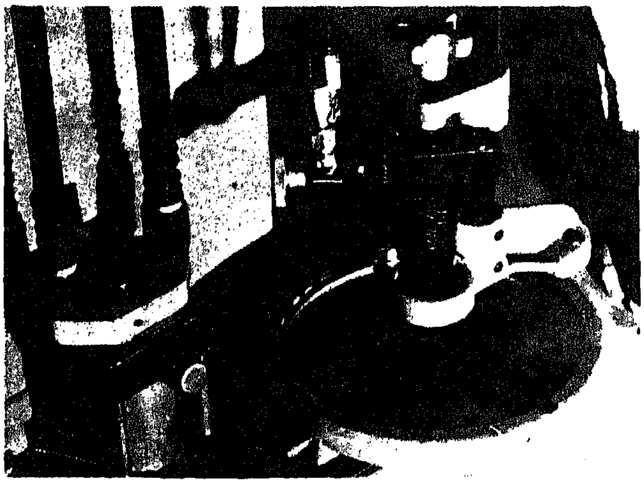


Fig. 6-1-43. Flanged mounted injector in ST-668 F60121

ST-790 Test Stand Installation and Calibration

Injector Test Stand — ST-790

The ST-790 Injector Test Stand is the recommended calibration equipment for testing and calibrating Cummins injectors, but it must be properly installed and calibrated to obtain the highest accuracy possible.

ST-790 Injector Test Stand (Fig. 6-1-44) is used to test all Cummins PT injectors. ST-790 flow tests the complete injector assembly by measuring fuel delivery. The injector is actuated under controlled conditions closely simulating actual operating conditions. The test stand counts injection strokes, supplying fuel at a specified pressure, thereby measuring the delivery in a glass graduate.

The ST-590 Test Stand was used prior to release of ST-790 and may be converted, ST-790 provides more accurate results, better clamping arrangement and easier operation. The accuracy and advantages of ST-790 Test Stand make it very important that ST-590 Test Stands be converted

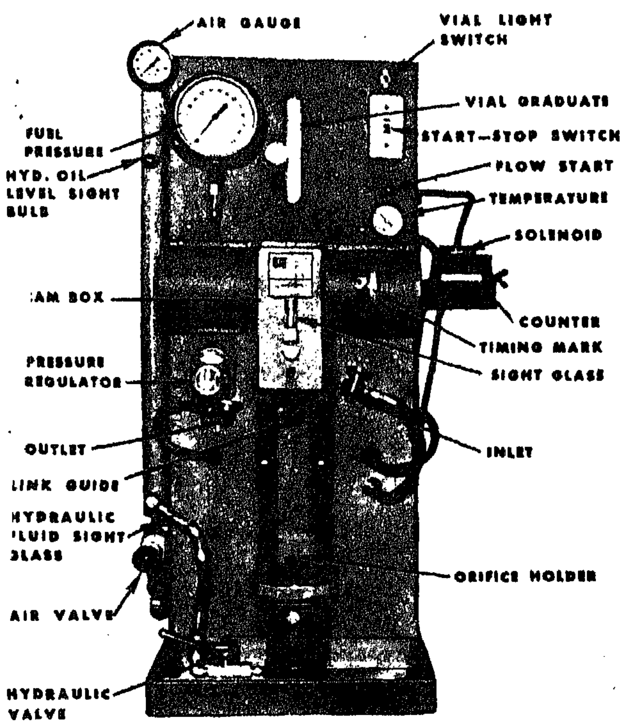


Fig. 6-1-44. Injector test stand ST-790 F60122

Description of Operation — ST-790

1. A motor driven shaft and a cam are housed in the cam box. The cam actuates the vertical push rod at the bottom of the housing.
2. The push rod is connected to the injector by a link so the injector plunger will be actuated by cam action just as it is in the engine. Fig. 6-1-45.
3. Injectors are clamped in the test stand by hydraulic pressure from the cylinder, piston rod and injector seat. The

Fig. 6-1-45. Link and injector in position F60123

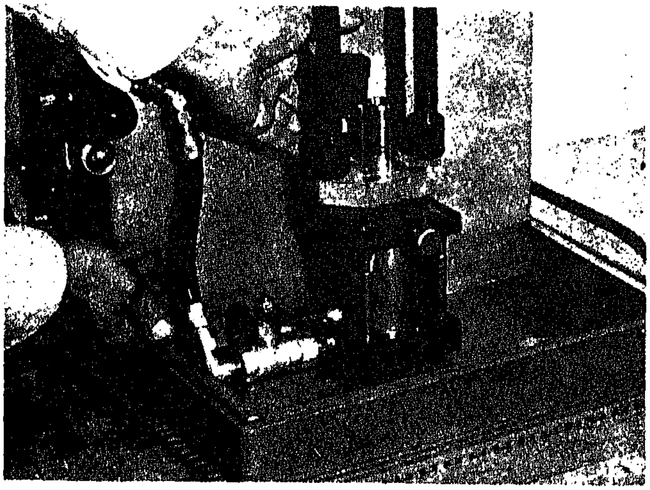


Fig. 6-1-46. Clamping cylinder and seat F60124

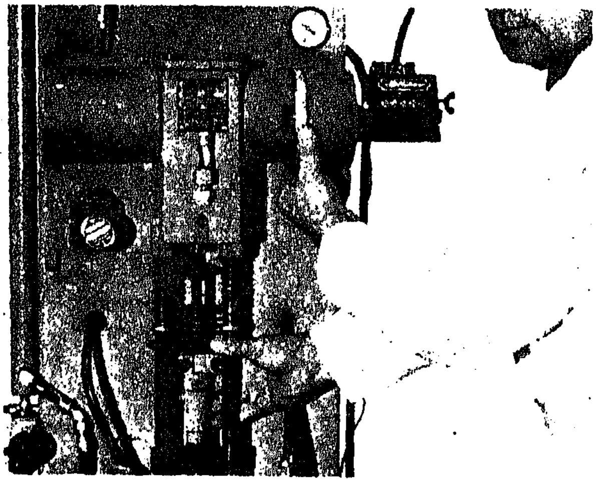


Fig. 6-1-47. Timing wheel F60125

injector seat contains a removable orifice to restrict the metered fuel flow and cause a back pressure simulating compression pressures as found in the engine. Be sure to use correct size orifice. Fig. 6-1-46.

4. Before clamping the injector in the test stand the cam must be timed by rotating the timing wheel so the wheel mark and pointer are aligned. Fig. 6-1-47.

5. Shop air pressure regulated by this air regulator is used to apply a balanced force on the hydraulic system. Fig. 6-1-48. The air gauge at top of hydraulic reservoir is used as a reference indicating that pressure has not changed, after being set using a load test cell during test stand calibration.

6. When the air valve is opened air travels up the pipe in the center of the tube type hydraulic reservoir and exerts a downward pressure against the column of hydraulic fluid. Fig 6-1-48.

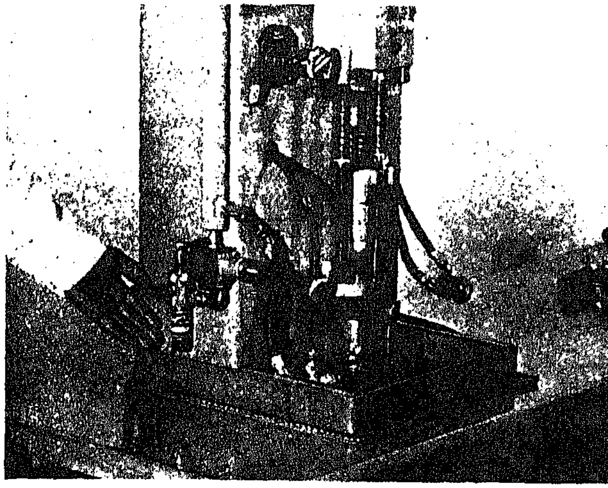


Fig. 6-1-48. Air pressure connection F6012

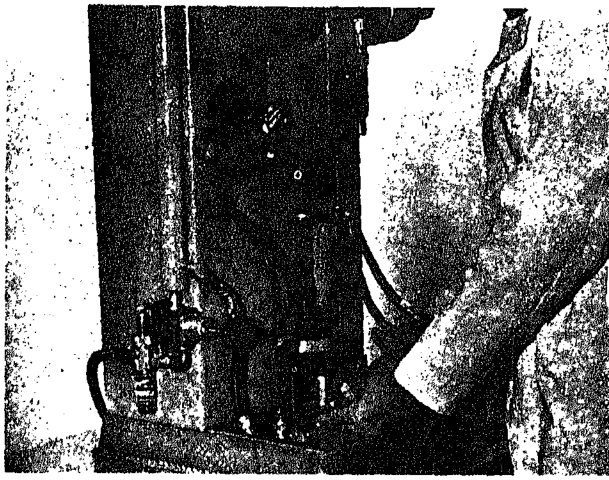


Fig. 6-1-49. Hydraulic valve F6012

7. When both the air valve and the hydraulic valve ar opened, hydraulic fluid is admitted under the piston in th cylinder and lifts the injector into clamped position. An leak in the hydraulic clamping system will directly affec injector loading and must not be permitted.

8. In clamped position and with the appropriate link in plac tension on the injector is the same as it is in the operatin engine. Use of the improper link will affect clamp load an upset delivery values.

9. Fuel is delivered to the injector through the inlet con nector. Fuel pressure here is controlled at this point by connecting line and pressure regulator. Fig. 6-1-50.

10. The second connection with the clear plastic line is the in jector drain connection which carries drain fuel from th injector back to the tank.

11. During test stand operation the operator starts a test cyc

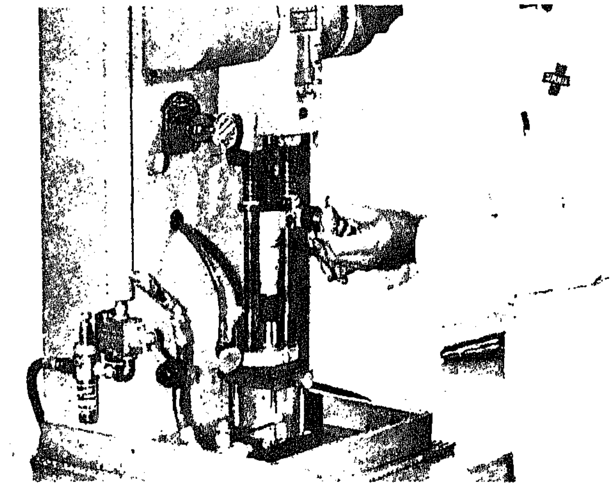


Fig. 6-1-50. Fuel inlet connector F60128

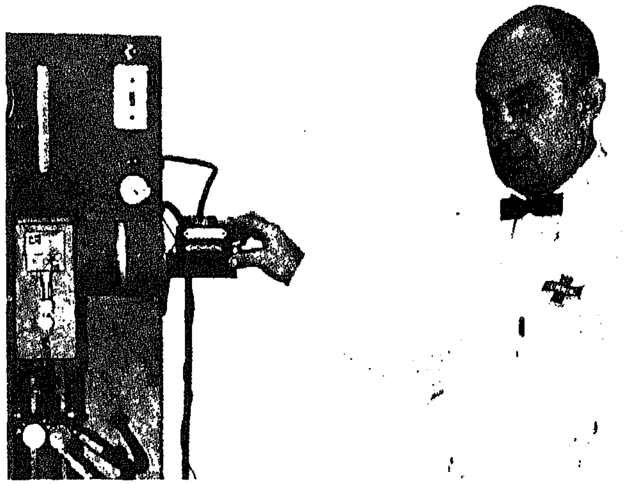


Fig. 6-1-52. Stroke counter F60130

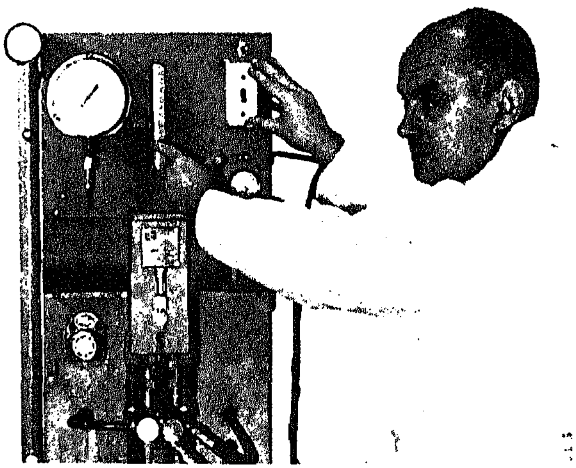


Fig. 6-1-51. Measuring fuel in vial F60129

which diverts fuel to the vial so the amount of fuel being injected can be measured. Fig. 6-1-51.

Fuel is delivered to the vial during a measured number of strokes as recorded by the counter. Fig. 6-1-52. The remaining parts of the test stand will be described as we go through the actual calibration procedure.

A master injector which has been previously calibrated at the factory is used in setting the test stand prior to adjusting other injectors for fuel delivery. **The master must never be tampered with.**

Flow Testing PT Injectors On ST-790

Flow Testing Adjustable Delivery Injectors On ST-790

ST-790 Test Stand is used to flow test the complete injector assembly by measuring fuel delivery. The injector is actuated under controlled conditions closely simulating actual operating conditions. The test stand counts injection strokes, supplying fuel at a specified pressure, thereby measuring the delivery in a glass graduate.

1. Remove master injector ST-768 from test stand after calibrating test stand. Install correct restrict orifice in cup seat, see Table 6-1-9, Fig. 6-1-68, and tighten to 6 inch pounds.

a. .0115 inch orifice has four notches.

b. .013 inch orifice has two notches.

c. .020 inch orifice has six notches.

Note: Delivery for injector with approximate strokes of 800 in Table 6-1-9 is established by setting ST-790 Stand with ST-768 Master Injector; then turning back the counter by 200 strokes. For example, if test stand counter was set at 1050 with ST-768 Master, the injectors to be tested would be run at 850 counter strokes.

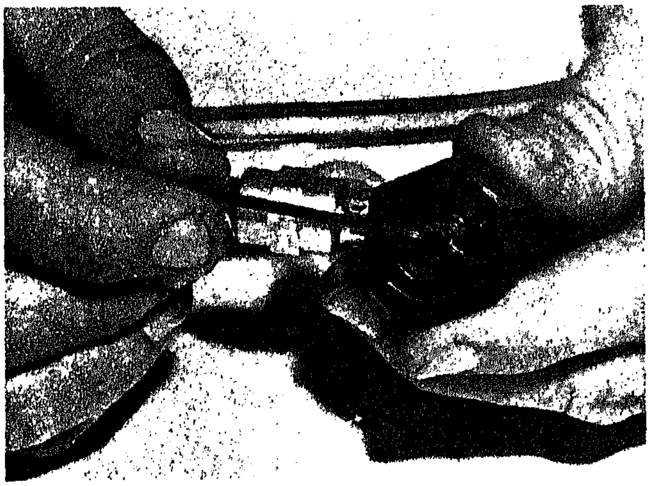


Fig. 6-1-68. Installing restrictor orifice F60142

Flanged Adjustable Delivery PT Injectors

1. Assemble the appropriate link (Table 6-1-11) and adapter to the injector.
2. Slide appropriate tie rod spring retainers against springs for injector.

Note: When flowing C Engine Series Injectors, th hold-down plate must be reversed and the "J" spacers c both tie rods are to be used.

3. Position injector in test stand with class size mark c plunger between inlet and drain ports.

Note: Check injector cup to make certain all carbon ha been removed from the cup seating area.

4. Check injector flow specifications for model injector to b tested. Table 6-1-9. Set pressure at 120 psi prior to de pressing flow start switch; pressure must be maintained 120 psi during injector test. Run injector through test cyc at 120 psi and check cc delivered in the vial.
5. If the fuel delivery is above or below proper flow specific tions, remove adjustable delivery orifice plug from injecto inlet.
6. Select a larger or smaller inside diameter orifice plug bring flow to proper value. See Table 6-1-10.

Note: A very useful tool for checking orifice inside diam eter is available directly from the Hamilton Watch Com pany, Lancaster, Penn., or their dealers as "Kwik Che Hole Gauge, Model C#20". This is especially helpful if or fice plugs become mixed. Measure orifice at base en (not wrench end) as shown in Fig. 6-1-69.

7. Install new orifice plug and tighten to 8 to 10 inch-pounc torque with a torque screwdriver or torque wrench.

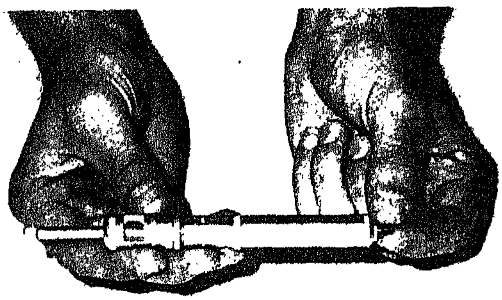


Table 6-1-9: Part and Delivery Values — PT Injectors (ST-790 Test Stand and ST-768 Master Injector)

BM-No. Complete Injector	BM-No. Body & Plunger	Reference Body Part No.	BM-No. Cup & Retainer or Gasket	Cup Spray Holes No. — Size X Angle	Delivery No. CC	Approx. Strokes	Flow Code	Pressure PSI	Injector Seat Orifice	Adjustable Orifice I.D. Range	Approx. Orifice Size Before Burnishing	Engine Model
AR50267	71819	131590	AR50265	8 — .006 X 14°	92-93	1000	93	120	.0115	.048-.060		C-180

8. Run injector through additional test cycles as necessary until orifice plug used will bring delivery into proper value.

   Note: Never use first reading as a final value.

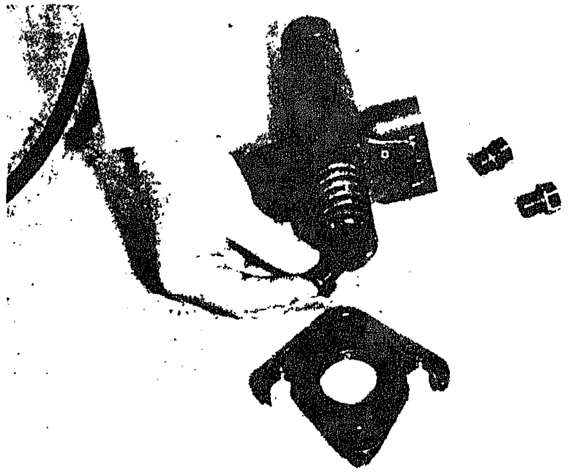


Fig. 6-1-70. L injector mounting parts for testing

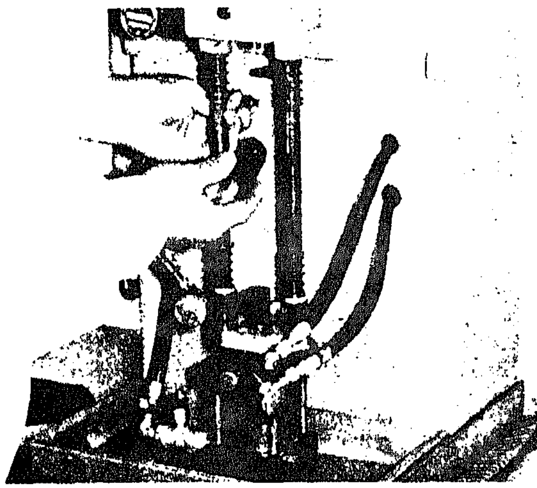
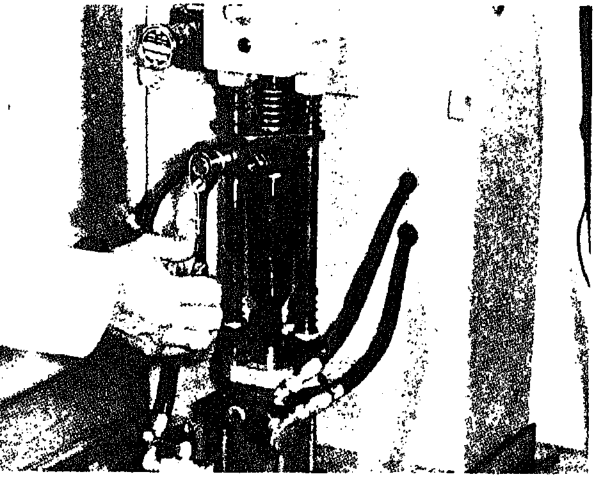


Fig. 6-1-71. Removing link guide



6-1-72. Attach fuel line adapters F60146

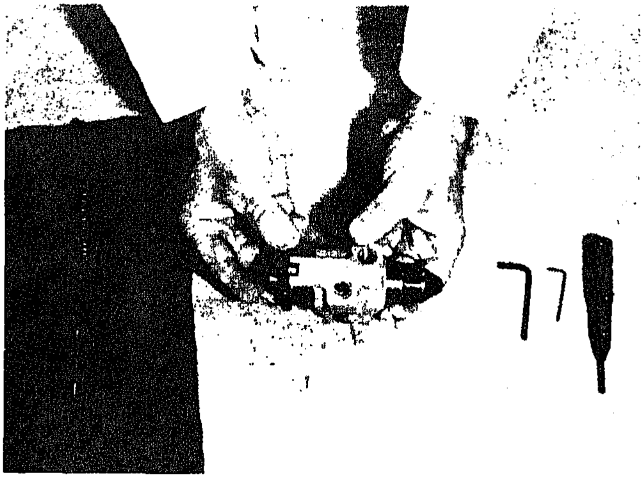


Fig. 6-1-73. Center injector inlet in ST-726 inlet hole F60150

Fig. 6-1-74. Rotate cam to seat F60151

Table 6-1-11: ST-790 Test Stand Link Data

Engine Series	Engine Bore & Stroke	Link Marking
C	$4\frac{7}{16} \times 5$	C

3. Check to be sure injector inlet is centered in ST-726 inlet hole.

4. Remove spring and plunger from body. Leave sprin and install plunger into body.

Note: Turn injector plunger so class size marking o of spring retainer is mid-way between inlet and drain of injector.

5. Perform ball valve seating before calibrating injector.

a. Attach test stand inlet pressure line to drain connecti ST-726 Body.

b. Hold injector plunger down against its seat in injecto with injector in a vertical position. Assembly may be in hand, do not place in test stand holding device. 6-1-75.

Note: Be sure ST-708 needle is retracted.

c. Turn on test stand, and adjust pressure to 150 psi.

d. Check orifice plug inlet opening of ST-726 Body for age past ball valve.

Note: Make sure plunger is seated in cup.

e. If leakage is observed, the ball must be re-seated. slight seepage is not harmful.

6. Reseat the ball valve if leakage is observed in Step
a. Disconnect fuel line and remove injector from ST-726

b. Remove the retainer plug at top of injector body. Leav ball in place, but discard the retainer gasket.

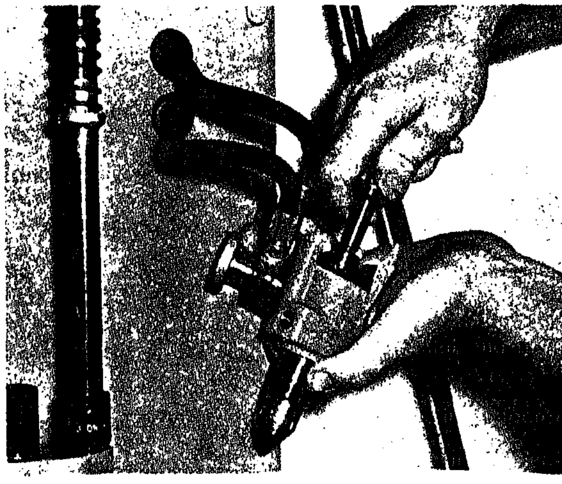


Fig. 6-1-75. Check leakage at inlet port

Cylindrical PT (Type B

1. Lubricate inside of ST-726 Body with Lubriplate so injector "O" rings will slide into adapter without damage to "O" rings.

Note: The ST-726 Body is used to hold cylindrical injectors while testing.

2. Seat injector in body so injector inlet aligns with body inlet as injector is rotated into ST-726 Body.

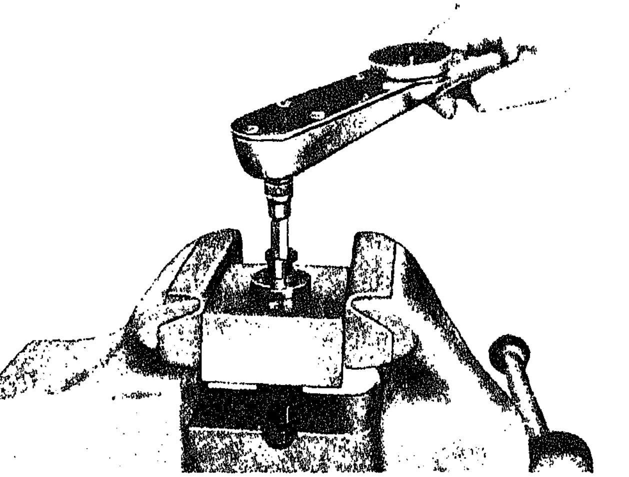


Fig. 6-1-76. Seating ball with ST-718 F60148

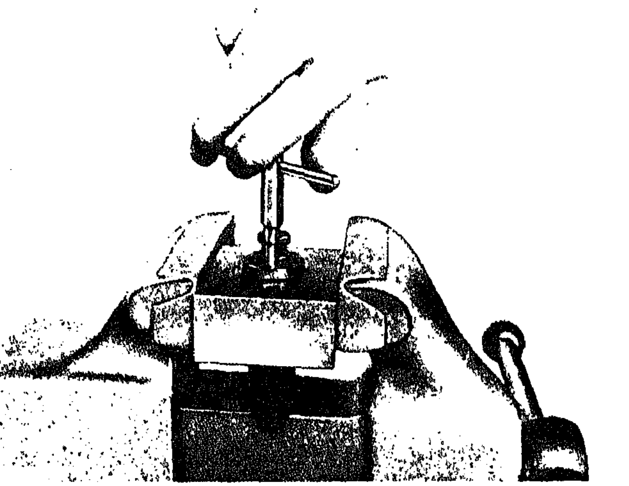


Fig. 6-1-77. Cutting ball seat with ST-955 ball seat cutter F60149

Screw ST-718 Seating Tool down against the ball and tighten to 30-40 inch-pounds torque. Fig. 6-1-76.

Remove ST-718 Seating Tool. Install the retainer plug with a new gasket. Tighten retainer to 30-40 inch-pounds torque.

Check injector for ball valve leakage as previously described. In rare cases it may be necessary to seat ball with ST-718 screwed to a maximum of 50 inch-pounds.

If ball does not seat satisfactorily after Step e, it will be necessary to resurface the ball seat using ST-955 Ball Seat Cutter. Fig. 6-1-77. Great care must be exercised in removing only enough material to reface a new seating surface and remove all metal cuttings.

Step 5 above must be repeated after ST-718 sealing operation or ST-955 cutting operation.

With injector installed in ST-726 body. Disconnect inlet pressure line from drain connection of ST-726 Body. Remove injector plunger.

8. Install ST-726 cam and rotate into notched seats

9. Seat injector so injector inlet aligns with ST-726 body after injector body is rotated into sleeve.

10. The cam pin must seat in slot of body.

11. Check to be sure injector inlet is centered in body inlet hole to prevent breaking ST-708 Burnishing Tool points when installed later.

12. Lock the cam on injector and sleeve with the two socket head capscrews.

13. Install spring and plunger into injector.

    Note: Turn injector plunger so class size marking on top of spring retainer is mid-way between inlet and drain ports of injector: Plunger should stay in this position until installed in engine, to obtain the same performance in engine as on the test stand.

14. Assemble retainer plate over injector with pins engaging in cam holes.

15. Position injector in test stand with correct adapter link. See Table 6-1-11.

    Note: All tests on test stand are performed without a screen on injector.

16. Assemble ST-708 Burnishing Tool into test stand injector inlet connector. Retract the needle by pulling out small knob. With needle retracted ST-708 tool may be left in connector during all test operations.

    Note: PT injector delivery is adjusted by burnishing the inlet orifice plug with ST-708 instead of changing the plug.

    The replaceable needle point is the burnishing member. Fig. 6-1-78.

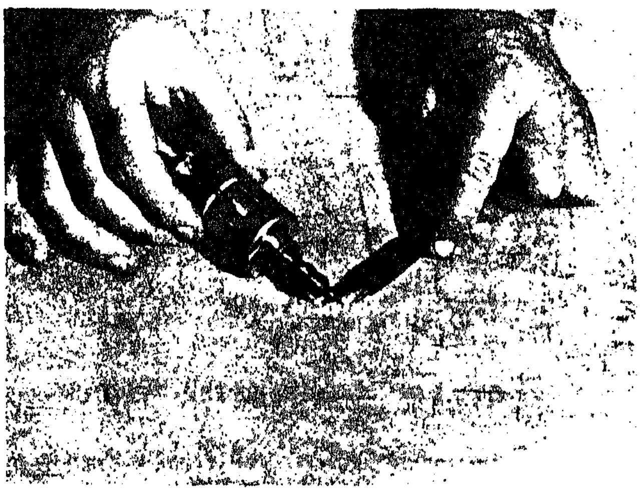


Fig. 6-1-78. ST-708 burnishing tool F60152

17. Install connector and ST-708 tool into ST-726 Body inlet by screwing in the large knob section. Fig. 6-1-79.

18. Install drain connection.

19. Run injector through a test cycle and check the cc delivery. If delivery is lower than specifications given in Table 6-1-9, turn the knob with indicator point until it is spaced 1/4 inch from the large knob. Fig. 6-1-81.

20. Slowly push the small knob in until you feel the needle enter the orifice plug inside diameter. Then turn the knob counter-clockwise to lock the needle shaft to the larger knob with the indicator. Turn the indicator knob in until you feel the needle contact the plug. Index the indicator with a mark on the largest knob and advance one mark for each two cc increased delivery. Fig. 6-1-82.

Note: Test stand must be running while burnishing orifice with ST-708.

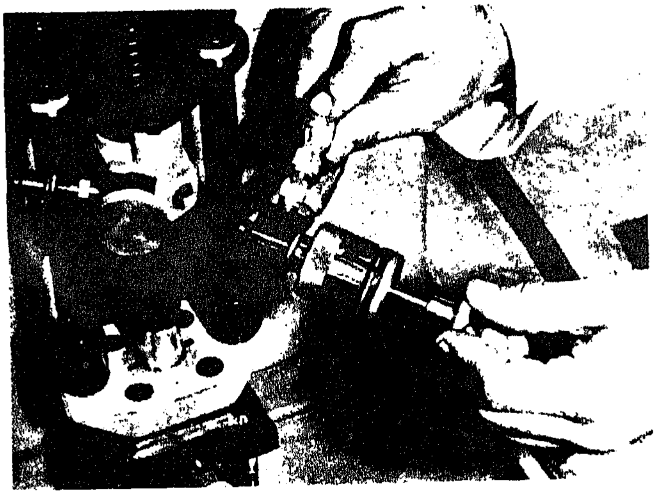


Fig. 6-1-79. ST-708 in inlet connection F60153

Fig. 6-1-80. Assemble tool to adapter F60154

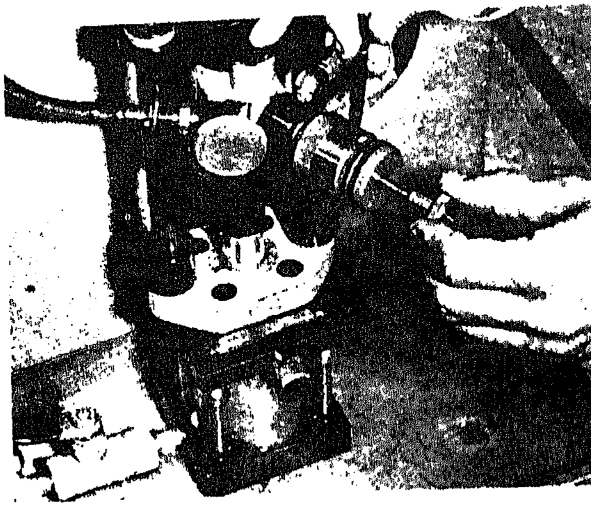


Fig. 6-1-81. Knob spacing

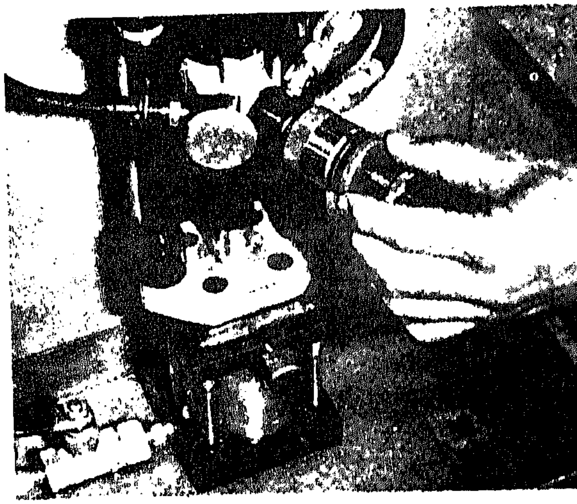


Fig. 6-1-82. Burnish operation

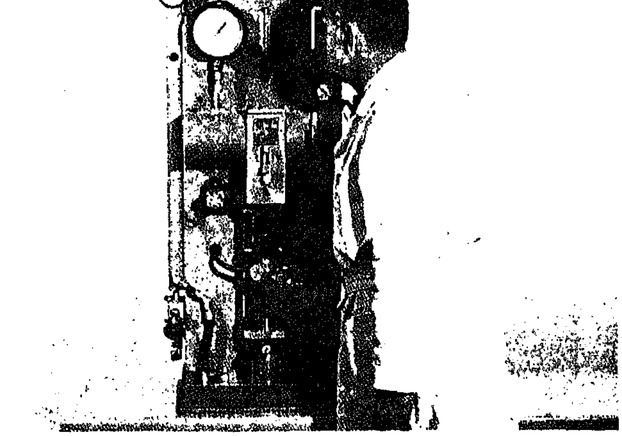
21. Back off adjusting screw and retract needle, th delivery.

22. If delivery is more than a specified cc (Table 6-1- adjustable orifice must be installed in the inje Table 6-1-12. Tighten orifice plug to 8 to 10 inc torque.

Note: Some orifice plugs have flanges and requi ket between flange and body. These plugs are tig 8 to 10 inch-pounds torque.

23. New inlet orifice plugs contain enough stock in diameter so a small displacement of metal by will increase delivery. The amount of displac limited so several orifice plugs are required to delivery for all the engine models from low to h power. See Table 6-1-12.

24. When delivery is correct (Fig. 6-1-83) remove nection and drain connection.



g. 6-1-83. Check cc delivery in vial F60157

emove injector from test stand.

emove plunger and spring.

emove adapter plate, cam and body from injector body.

stall plunger and spring in injector body. Position the unger class mark at mid-way between inlet and drain orts.

able 6-1-12: Orifice Plugs for PT (type B Injectors

raight art umber	Inside Diameter	Flanged Part Number	Inside Diameter
3065	.015	177283	.015
3066	.016	177284	.016
3067	.017	177285	.017
8338	.018	177286	.018
3068	.019	177287	.019
3069	.020	177288	.020
3070	.021	177289	.021
3071	.022	177290	.022
9726	.023	177291	.023
3072	.024	177292	.024
3073	.025	177293	.025
3074	.026	177294	.026
3075	.027	177295	.027
3076	.028	177296	.028
3077	.029	177297	.029
3078	.030	177298	.030
3079	.031	177299	.031

wrap-around screen is used, wrap around injector over ifice so lap does not cover orifice, then secure screen clip. Position clip so slot is located over orifice.

flanged orifice is used insert disc screen over orifice nd assemble retainer ring to hold screen in place.

ote: Pull plunger and spring from body, install mounting plunger so class size mark on top of spring retainer is mid-way between inlet and drain ports of injector.

PT Injector Group

Assemblies included in this group are fuel tubing, fittin and connections.

Fuel Tubing, Fittings and Connections—Unit 60

Fuel Tubing and Fittings

Reject any fuel tubing or tubing fittings that are:

1. Not standard size or length.

   Caution: Note Fig. 6-2-1, which illustrates two different angle fittings used on Cummins wire braid hose. Failure to use proper combinations may cause air or fuel leaks.

2. Twisted or bent out of shape.
3. With damaged threads.

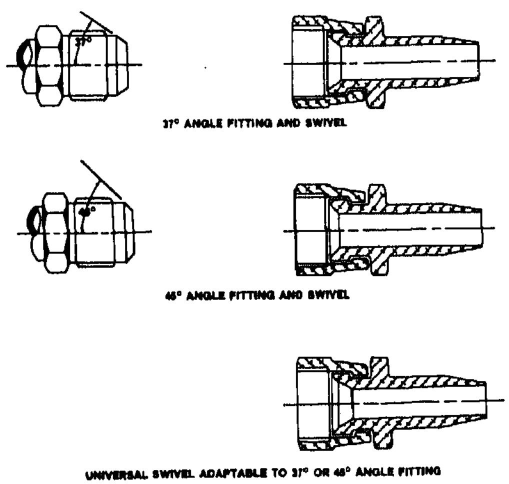


Fig. 6-2-1. Wire braid hose fitting and swivel angles F60184

Fuel Inlet and Drain Connections

Fuel connections are used only with flanged injectors.

1. Remove strainer screen from inlet connection. Fig. 6-2-3.
2. Clean screen in solvent and dry with an air jet, blowing in reverse direction of fuel flow.
4. Inspect threaded end of all connections; replace if threa are damaged.
5. Replace copper gasket, rubber "O" ring and retainer.

   Note: Fuel line and tank specifications are given in B letin 983535.

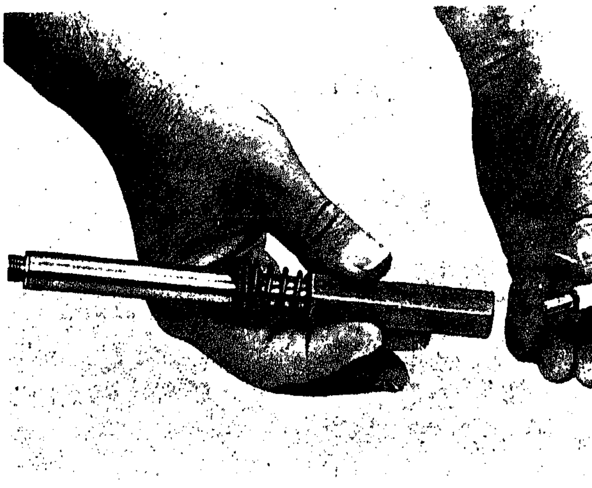


Fig. 6-2-2. Removing injector inlet screen F6

Lubricating System

The lubricating system group consists of the oil pan, lines, dipstick, filters, coolers, oil pumps and pressure regulators.

Lubricating Oil Pan—Unit 701

Specifications

The extreme angular operation at which a vehicle is to be operated must be known and a lubrication system provided that is suitable for the maximum angle of operation. Engines for automotive vehicles should be protected to at least 10° vehicle angularity of operation and engines for construction equipment must be equipped with the necessary components to permit at least 30° vehicle angularity of operation. A double lubricating oil pump is available to be used on engine applications where extremely high angularities are encountered. See Table 7-1-1 for oil pan capacities, sump location and permissible angularity.

Disassembly

1. Remove all gasket material from oil pan mating surfaces.
2. Remove damaged helicoil inserts.

Cleaning And Inspection

1. Steam clean pan and all mounting parts.
2. Clean cast iron or steel pan in hot solvent tank.

Caution: Do not use solvent that will harm non-ferrous metal (aluminum, copper, brass, solder).

3. Visually check oil pan for cracks or, if a leak is suspected, check using dye penetrant.

a. Spray suspected area with dye penetrant.

b. Allow penetrant to dry for fifteen minutes. Do not "force dry."

c. Spray area with dye developer.

d. Check for crack indications.

4. Check helicoil inserts on aluminum oil pans. If lost or damaged mark for replacement.
5. Check all threaded holes for damaged threads.

Repair

1. Repair lost or damaged helicoil inserts.

a. Determine hole size; then use proper helicoil extraction tool to remove damaged helicoils. Condition hole and insert new helicoil. Refer to Service Tool Catalog for proper helicoil tool.

b. Use starting and finishing tap for helicoil inserts for new or oversize holes in aluminum. When tapping aluminum, use fuel oil for lubricant to prevent tearing. Fig. 7-1-1.

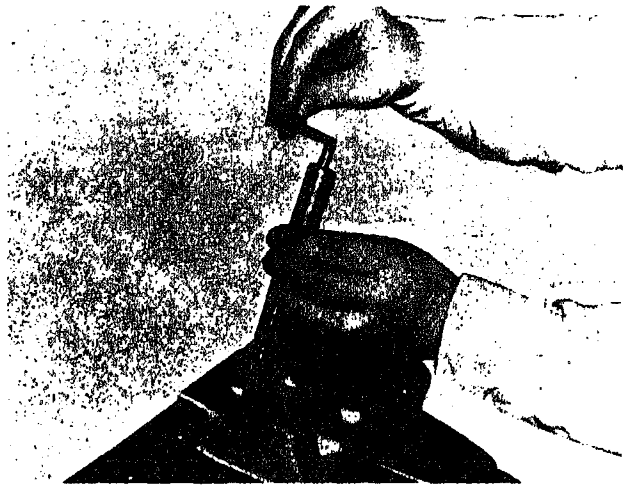


Fig. 7-1-1. Installing helicoil insert in oil pan N10702

c. After inserting helicoil, bend starting end toward center then back toward side of hole to break off installation tip.

2. Repair small cracks in pan by welding. **Do not weld** finished surfaces.
3. Repair oil plug drain hole in aluminum or die cast oil pans when drain hole threads are damaged. Two oversize plugs are available to permit re-thread of oil pan drain holes at least twice.

a. Part No. 62117 Oil Pan Drain Plug; Size 1¼ in. x 12 thread.

(1) Enlarge damaged hole by drilling to 1¹¹⁄₆₄ in. [29.7656 mm].

(2) Tap hole with a 1¼ in. x 12 tap. When tapping aluminum, use fuel oil for lubricant to prevent tearing of metal.

(3) Install new drain plug with a new copper gasket. Tighten to 60/70 ft. lb. [8.2980/9.6810 kg m] torque.

b. Part No. 120349 Oil Pan Drain Plug; Size 1⅜ in. x 12 thread.

Table 7-1-1: Oil Pan Capacity U.S. Gallons [Liters] And Angularity (Continued)

Part No.	Sump Location	No. Cyl.	Eng. Mtd. Tilt Angle	Capacity Hi	Low	Engine Model
08137	Front & rear	6	0°	4 (15.140)	3 (11.355)	C

Enlarge damaged hole by drilling to $1\frac{19}{64}$ in. [32.9406 mm].

Tap hole with a $1\frac{3}{8}$ in x 12 tap. When tapping aluminum use fuel oil for lubricant to prevent tearing of metal.

Install new drain plug with a new copper gasket. Tighten to 60/70 ft. lb. [8.2980/9.6810 kg m] torque.

Assembly

Install pipe plugs to oil pan securely. ***Do not overtighten.***

Apply new gasket to oil pan-to-block mating surface. Be sure mating surface is clean of all old gasket material before applying new gasket.

Lubricating Oil Lines—Unit 702

Specifications

1. Hose used for lubricating oil or fuel should consist of a seamless synthetic rubber inner tube reinforced with fabric braiding and wire braiding, and covered with a synthetic rubber-impregnated oil-resistant fabric braid or rubber coating.

2. The minimum flexible hose sizes required for lubricating oil plumbing are given in Table 7-2-1.

3. The hose should be capable of handling fluids ranging in temperature from —40° to 300° F. [—40° to 148.9° C.] and be suitable for use with lubricating oil and/or fuel oil.

   Caution: Since engine lube oil temperature may exceed 250° F. [121.1° C.] at full load operation and high ambients, hose meeting SAE specifications 100 R 1 and 100 R 5 will not be adequate unless it is also capable of handling fluids within the temperature range as stated above.

4. Hose subject to high incidence of salt spray from road splash or on marine engines may require the use of corrosion-resistant wire braid or protective vapor-resistant wire braid or protective rubber covering, and should have brass hose fittings and adapters.

5. On those installations where there is high relative movement between parts connected by lube oil hose, such as filters mounted on frames and plumbed to the engine, consideration should be given to the use of premium-type hose material to avoid rubber fatigue which results in oil seepage and possible rupture of the hose liner.

6. Consideration should also be given to the clamping of hose; that is, enough flexibility has to be provided to accommodate the relative movement and at the same time clamps should be located as required to prevent chafing of the hose.

Cleaning

1. Clean all lubricating oil hose, inside and outside, in a tank of suitable solvent.

2. Dip hose in a hot-water tank and dry with compressed air, inside and outside.

3. Flush all flexible lubricating oil hose with a water solution containing a good grade soap cleaning compound at not

Inspection

1. Inspect oil connections, flanges and tubing for cracks; ject if defective.

2. Inspect flexible hose for defects and deterioration. Rej hose that has become hard and brittle. Check for rais or swollen spots. Since flexible hose usually begins to teriorate on the inside, the hose should be thoroug checked for signs of internal collapse. If hose should c lapse, the lubricating oil flow would be seriously restrict

Repair

Replace defective or cracked hose and connections v new parts. Average life of the flexible oil hose is 100,00 200,000 miles [160,900 to 321,000 km] or 3200 to 6400 ho depending upon amount of bend and temperature to wh hose is subjected. For shops equipped to make up h from bulk hose, follow steps below to insure proper fit installation.

1. Cut hose to the required length using a hacksaw.
2. Hose cut should be square within 5°.
3. Lay hose flat before cut is made.
4. Hose should not be crushed while sawing (crushed h will permit nipple to pick up hose inner tube and bl passage).
5. Place socket in jaws of a vise.

   Note: Check all fittings to make sure of fit on mating p see "Fittings" following.

6. Rotate hose counterclockwise while pushing it into soc
7. Hold hose so that it enters socket straight to prevent co ing of hose in socket.
8. Turn hose into socket until it bottoms.
9. Check hose to be sure it has bottomed and does not in from being pushed in too far.
10. Place socket and hose assembly in jaws of a vise. (Cl on the socket.)
11. Apply lubrication on nipple and inside of hose for eas assembly using SAE 40 oil.
12. For Stratoflex Type 211 or Aeroquip Type 1503 hose, h assembly tools are available for assembling nipple ass blies into hose and socket assembly. These tools hav

ised on hose sizes 4 through 12. Reference: Aeroquip Corp. Tool Kit #1597 SAE, for sizes 16 through 24 or Kit #1667 P.T.T. for Stratoflex Type 213 hose; the nipple may be assembled to the hose and socket assembly by turning the nipple into the socket using an appropriate wrench on the nipple hex.

For Stratoflex Type 211 or Aeroquip Type 1503, the swivel nut and nipple can be easily assembled to socket and hose if nut and nipple assembly are first tightened on an adapter. With adapter-type assembly unit, a drill which closely corresponds to I.D. of fittings should be used as a pilot to start nipple into socket and base assembly. Adapters are not required for use with Stratoflex Type 213 hose.

Assemble nipple in socket and hose assembly.

On swivel assemblies there should be 1/32 to 1/16 in. [0.7937 to 1.5875 mm] clearance between nut and socket for Stratoflex 211 or Aeroquip Type 1503 hose. No clearance should be allowed for Stratoflex Type 213 hose.

Remove hose assembly from vise.

Inspect: no inner tube shavings are allowable.

Table 7-2-1: Hose Size

Location	Minimum Hose Size
Full-Flow Filter	No. 12
Turbo. Oil Supply	No. 6
Turbo. Oil Drain	No. 16
By-pass Filter	See Unit 704

Suction Tube

Remove the mounting capscrews from flange-mounted suction tube to lube pump body.

Remove retaining clip and screen from suction bell.

Clean screen and tube; soak in solvent, dry with compressed air.

Inspect parts for damage and replace as needed.

Reassemble screen.

Where "O" rings are used on the suction tubes, install new

Table 7-2-2: Hose Bends — In. [mm]

Hose Size	Inside Dia.		Outside Dia.		Minimum Bend Radius	
4	3/16	[4.7625]	31/64	[12.3031]	2	[50.800]
5	1/4	[6.350]	35/64	[13.8906]	2-1/4	[57.150]
6	5/16	[7.9375]	39/64	[15.4781]	2-3/4	[69.850]
8	13/32	[10.3187]	47/64	[18.6531]	4-5/8	[117.475]
10	1/2	[12.700]	53/64	[21.0343:	5-1/2	[139.700]
12	5/8	[15.875]	61/64	[24.2093]	6-1/2	[165.100]
16	7/8	[22.225]	1 13/64	[30.5593]	7-3/8	[187.325]
20	1-1/8	[28.575]	1 31/64	[37.7031]	9	[228.600]
24	1-3/8	[34.925]	1 23/32	[43.6562]	11	[279.400]

Fittings

Fig. 7-2-1 illustrates two different angle fittings used on wire braid hose. The bottom coupling illustrates a universal fitting to be used with either of the fittings shown. Always check for correct mating parts. Failure to use proper combinations may cause air or fluid leaks.

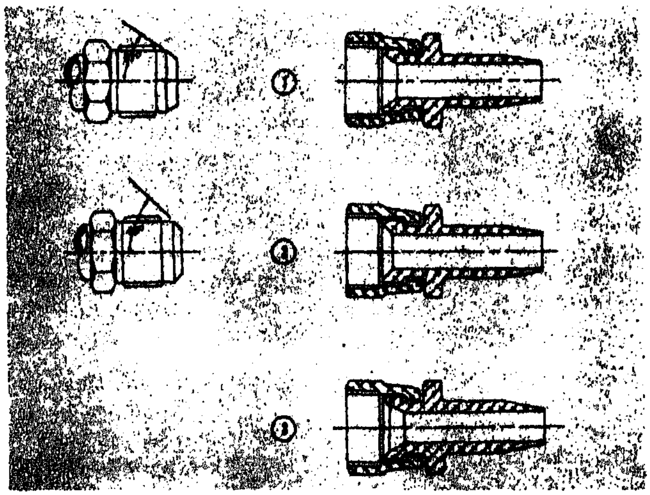


Fig. 7-2-1. Hose fittings N20725

Reference Fig. 7-2-1:

① 37° angle fitting and swivel.

② 45° angle fitting and swivel.

③ Universal swivel adaptable to 37° or 45° angle fitting.

Lubricating Oil Dipstick—Unit 703

The dipstick supplied on each engine to check the oil level has been calibrated for a certain oil level when used with a specific oil gauge tube and with the engine in a certain position (angle of tilt sideways and fore and aft). Normally, a dipstick may be used for engine power angles $\pm1°$ from the angle specified for that particular dipstick. Too high an oil level will cause foaming, excessive oil temperature and power loss. Too low an oil level will result in oil pressure fluctuation and possible loss of oil pressure.

In the event a dipstick should be lost or damaged and a new dipstick is required:

1. If part number is known, from original engine parts list or from part number on old dipstick, replacement number should be used and recorded so further servicing problems will be avoided.

2. If it becomes necessary to mark a blank dipstick for use, see Table 7-3-1 for lengths available. Use straight or flexible dipstick, as required.

Table 7-3-1: Blank (Unmarked) Dipstick Length

Part Number	Type	In.	[mm]
131461	Straight	11-7/16	[290.5125]
131462	Straight	23-1/4	[590.550]
131463	Straight	47-11/16	[1211.2625]
161482	Flexible	20	[508.000]
161483	Flexible	40	[1016.000]
161484	Flexible	60	[1524.000]

a. Determine oil pan part number; check high and low capacity. Table 7-1-1.

b. Place equipment where engine is in level or normal operating position.

c. Drain all oil from oil pan; drain both sumps, if engine is so equipped. Make sure all oil has drained down from engine.

d. Fill oil pan with amount of oil indicated as low level in Table 7-1-1. Make sure oil goes into sump containing dipstick; allow sufficient time for oil to drain down into the pan. Where possible it is best to put clean oil directly into pan to get most accurate results.

tube, remove dipstick and cut off end the same amount measured protrusion (to bottom of cap).

f. Insert dipstick all the way into tube. Remove dipstick a mark low oil level indicated. Mark should be 0.010 in. [0.2 mm] deep. Stamp (electric etch on spring steel) letter " immediately above mark.

g. Cut excess length off dipstick leaving minimum of ½ [12.7000 mm] below low level mark.

h. Add amount of oil to pan to bring to high level as indica in Table 7-1-1. Allow time for all oil to drain into pan.

i. Insert dipstick and withdraw; now mark oil level indicat Stamp letter "H" immediately above mark.

Lubricating Oil Coolers—Unit 705

Standard Oil Cooler

Disassembly

1. Remove cooler cover and discard gasket.
2. Remove top exposed "O" ring, under brass retainer, being careful not to scratch or mar sealing surface on element.
3. Use mineral spirits or equivalent to clean out lube oil and contaminants trapped in housing by forcing cleaner through the oil ports.
4. To remove element from housing, insert two $\frac{7}{32}$ in. [5.5562 mm] rods 8 in. [503.200 mm] long into the outside row of tubes opposite each other.

   Note: The rods should not drag bottom of housing.

5. Place a flat bar on top of housing and bundle face, between rods, and rotate element in housing to unseat lower "O" ring.

   Note: While turning element lift up gradually on rods to free "O" rings. When up about $\frac{5}{32}$ in. [3.9687 mm], element should be free to lift out of housing.

Fig. 7-5-1. Pulling oil cooler element N20716

Cleaning and Inspection

1. To prevent hardening and drying of foreign substances, cleaning solvent that will not harm non-ferrous metal.
2. Finish cleaning by blowing through bundle with compresse air.
3. Inspect element for corrosion or cracks where tubes ar welded to end plates.
4. Clean housing and connections in approved cleaning so vent and *inspect for cracks or damage.*
5. Inspect rubber hose clamps; replace as necessary.
6. Inspect lubricating oil cooler assemblies for leakage be tween oil and water passages.

a. Clamp housing and cooler element assembly in fixture an assemble air connection.

b. Place unit in water tank and apply 1 to 4 psi [0.07031 t 0.28124 kg/sq cm] air pressure.

c. Inspect for air leaks at pipe plugs, porosity in casting, an air leaks past "O" ring seal.

d. Apply line air pressure, 35/40 psi [2.4605/2.8120 kg/sq cm

e. Inspect for air leaks as per step "c".

Repair

Repair damaged tubes by inserting a smaller O.D. tube i side damaged tube. Cut and flare ends; then solder se curely. *Do not restrict more than 5% of total number* tubes in this manner. If more than 5% of tubes are defe tive, discard element.

Caution: Do not damage adjacent tubes with heat whi soldering.

Assembly

1. Lubricate rubber "O" ring and place in groove at botto of housing just prior to installing element. Make sure rir is not twisted and is free of cuts or nicks.
2. *Push element into housing,* aligning index marks on hou ing and element. See Fig. 7-5-2.
3. Press second "O" ring around top of element with a woo en block to assure equal pressure around ring circumfe

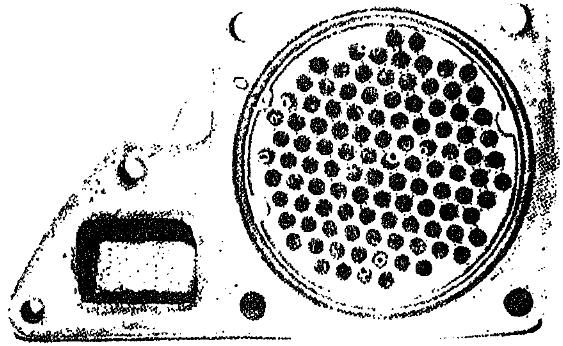


Fig. 7-5-2. Oil cooler element index marks N20717

Place new retainer ring over rubber "O" ring.

Assemble new gasket and front cover to housing.

Auxiliary Oil Cooler

Disassembly

Remove all flanges, hose and connections from oil cooler.

Remove cover plates from oil cooler and water cooler sections of oil cooler.

Remove core from housing if removable type.

Note: To prevent hardening and drying of foreign substances, clean core or cores as soon as possible after removal.

Cleaning (Oil Side)

Immerse the core in carbon tetrachloride or trichlorethylene or in other approved cleaning solvent. Let unit stand in solvent for several minutes. Force cleaner around tubes with hand rubber suction cup or with hand or motor-driven pump. Continue until clean.

Caution: This operation should be done in open air or in a well-ventilated room to avoid toxic effect of chemicals being used.

If oil passages are badly clogged, circulate an oakite or alkaline solution through the tubes. After cleaning, flush thoroughly with hot water.

Note: Flush inside of tubes with clean, light oil after both oil and water sides of cooler have been cleaned.

Cleaning (Water Side)

1. Immerse core of oil cooler in solution of one part muriatic acid and nine parts water after adding 1 lb. [0.4536 kg] of oxalic acid and .01 gal. [0.0379 lit] of pyridene to each 5 gal. [18.925 lit] of acid.
2. Remove core when foaming and bubbling stops. This usually takes 30 to 60 seconds.
3. Immerse unit in a 5% solution of sodium carbonate. Remove when bubbling ceases and pressure flush with clean warm water.
4. Clean inside of case thoroughly with steam, or solvent, or both.

Inspection and Repair

1. If leak occurs in a tube, repair by inserting a smaller O.D. copper tube inside the damaged tube.
2. Cut and flare ends of smaller tube and solder both ends securely.
3. Be careful not to damage adjacent tubes with torch flame.
4. Do not restrict more than 5% of total number of tubes in this manner. To do so would result in an undesirable increase in operating temperature, as well as considerable pressure drop.

Assembly and Testing

1. Install oil cooler units in housing.
2. Replace all old gaskets and "O" rings with new ones. Dip new gasket in light machine oil for 1 or 2 minutes before installing.
3. Assemble covers and mounting brackets with capscrews and lockwashers.
4. Seal core outlet.
5. Seal inlet with fitting designed for application of air hose and gauge.
6. Subject core to 35/40 psi [2.4605/2.8120 kg/sq cm] allowing only atmospheric pressure in the casing.
7. Permit unit to stand for 15 to 20 minutes, then check pressure gauge for pressure drop which will denote a tube or header leak.
8. To test case, seal coolant outlet and seal casing with water; then follow same procedure as in the core test. A pres-

sure drop on gauge will denote a casing leak.

9. If core is not intended for immediate use after repair and test, it should be prepared for storage.

a. Allow unit to drain thoroughly and blow out remaining liquid with air.

b. Flush light machine oil or soluble oil through tubes and drain off excess.

c. Seal all inlets and outlets to prevent entrance of dirt or foreign matter.

Lubricating Oil Pump—Unit 706

Double Lubricating Oil Pump (6-Cyl. Engine)

Disassembly

1. If not previously removed, remove suction tube assembly from oil pump.
2. Remove capscrews and lockplates (15, Fig. 7-6-3) securing scavenger pump housing to main pump housing. Remove scavenger pump housing (16) and gasket (10). Discard gasket.

Table 7-6-2: Double Lubricating Pump Dimensions

Part Description (See Fig. 7-6-3 for number referenced in parentheses)	**New Min.** In.	[mm]	**New Max.** In.	[mm]	**Worn Limits** In.	[mm]
Idler and Drive Shaft Bushings (2)	0.6165	[15.6591]	0.6175	[15.6845]	0.6185	[15.70
Idler Gear Bushing (7)	0.9925	[25.2095]	0.9935	[25.2349]	0.9945	[25.26
Idler and Drive Shaft Outside Diameter (25, 28)	0.6150	[15.6210]	0.6155	[15.6337]	0.6140	[15.59
Idler Gear Spindle Shaft (26)	0.9900	[25.1460]	0.9910	[25.1714]	0.9890	[25.12
Gears Outside Diameter (19, 5)	1.8320	[46.5328]	1.8330	[46.5582]	1.8310	[46.50
Bodies, Gear Pockets (1, 10) Minor Diameter	1.8400	[46.7360]	1.8420	[46.7868]	1.8430	[46.8

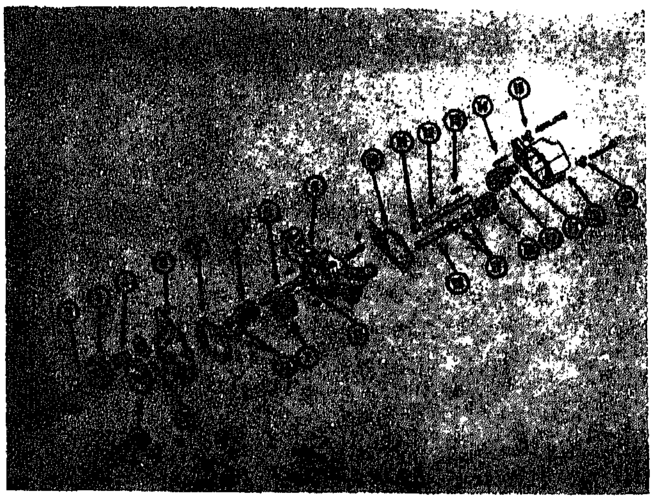


Fig. 7-6-3. Six-cylinder double lubricating oil pump — exploded view N20791

3. Inspect scavenger-to-main pump housing dowe loose or damaged, remove.
4. Remove scavenger driven gear (18) and idler g (19) from main housing. Inspect bushings (11). If damaged, press out and discard.
5. Check scavenger housing bushing (11). If worn o remove from housing and discard.
6. Remove lockwires and capscrews securing idler tainer (1) to cover (5). Remove retainer.
7. Remove idler gear (3), thrust washer (20) and idler from cover.
8. If idler gear bushing (2) is worn or scored, press discard. See Table 7-6-2 for wear limits.
9. Remove lockwires, capscrews and lockplates cover (5, Fig. 7-6-3) to main pump housing (9). Insp housing dowels. If worn or loose, pull and discard gasket (6).
10. Press drive shaft (8) from driven gear cover (5) (7) that rides in main housing.

nspect bushings in cover. If worn, scored or damaged, ress out.

Press scavenger drive shaft (12) from main housing gear 7) and main housing.

Press scavenger drive shaft from scavenger drive gear (17) and remove key (13) from shaft.

Check main housing bushings (11). If worn or scored, press out and discard.

Cleaning and Inspection

Clean all disassembled parts in approved cleaning solvent.

Check both housings carefully for obstructions in oil passages.

nspect gears for broken or chipped teeth.

Recheck all bushings and shafts for scoring, wear or damage. See Table 7-6-2.

nspect housings and cover for cracks, stripped threads or other damage. Retap stripped threads.

Assembly

Press new bushings into housings where removed.

Position key on scavenger pump drive shaft (12, Fig. 7-6-3); align slot of scavenger pump drive gear with key and press gear (17) onto shaft.

Insert scavenger pump drive shaft (12) through pump housing bushing (11). Press main housing gear (7) onto shaft.

If bushings were removed from pump cover, press in new bushings.

Press other main housing gear into place on drive shaft (8).

Insert drive shaft through bushing on lubricating pump cover; press oil pump driven gear (21) onto pump drive shaft (8).

If dowels were removed, position dowels on main pump housing.

Position gasket and cover (5) on housing (9); secure with lockplates and capscrews.

If idler gear bushing (2) was removed, press a new bushing into idler gear (3).

Position idler gear shaft (4), thrust washer (20), idler gear, and idler gear retainer (1) on cover; secure with capscrews.

If bushing (11) was removed from scavenger pump housing (16), press in new bushing.

If bushings (11) were removed from scavenger pump idler gear (18), press a new bushing flush on each side of gear.

13. Install scavenger pump idler gear shaft (19) in scavenger pump housing and position scavenger pump driven gear (5) on shaft.
14. Replace dowel (14) in housing, if removed.
15. Position gasket (10) and scavenger pump housing on lubricating pump housing; secure with capscrews and lockplates.
16. Lockwire capscrews.

Pressure Regulator—Unit 707

The pressure regulator is a part of the filter head

Disassembly

1. Remove spring retainer cap from pressure regulator housing and discard gasket.

   Caution: Remove cap with care to relieve spring tension.

2. Check housing for cracks and distortion; discard if damaged.
3. Check all other parts for damage and wear. See Table 7-7-1 for limits.

Assembly

1. Position low-pressure plunger on high-pressure plunger; insert into housing bore.
2. Insert spring in high-pressure plunger bore; position new gasket on cap and secure spring in plunger bore.
3. For operation of pressure regulator, see Figs. 7-7-1, 7-7-2, 7-7-3.

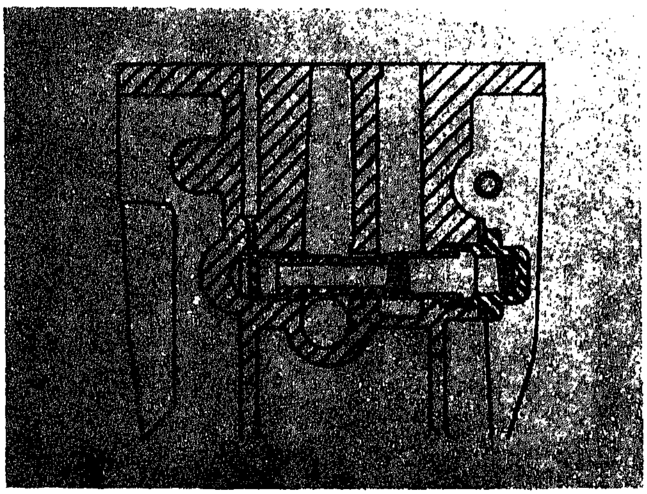


Fig. 7-7-1. Lubricating oil pressure regulator by-pass — cold-start position **N20722**

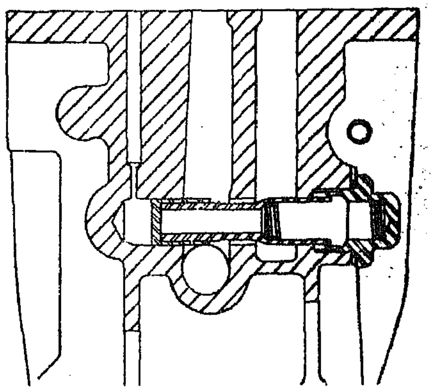


Fig. 7-7-2. Lubricating oil pressure regulator by-pass — warm-up position N

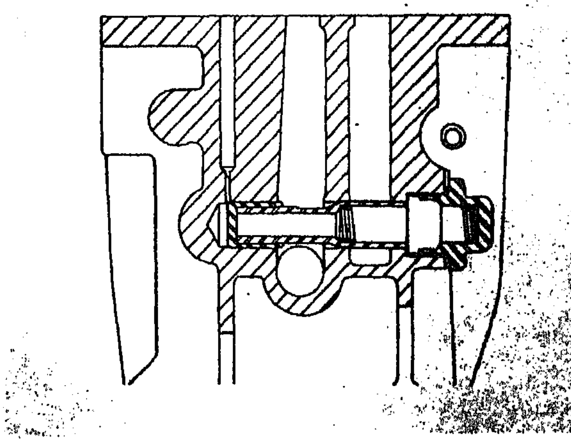


Fig. 7-7-3. Lubricating oil pressure regulator by-pass — normal operating position N

able 7-7-1: Pressure Regulator Dimensions

	Minimum		Maximum		Worn Limit	
lunger or Part	In.	[mm]	In.	[mm]	In.	[mm]
ow Pressure						
Inside Diameter	0.621	[15.7734]	0.626	[15.9004]	0.627	[15.9258]
Outside Diameter	0.740	[18.7960]	0.741	[18.8214]	0.739	[18.7706]
igh Pressure						
Large Outside	0.740	[18.7960]	0.741	[18.8214]	0.739	[18.7706]
Small Outside	0.615	[15.6210]	0.617	[15.6718]	0.614	[15.5956]
ousing Bore	0.740	[18.7960]	0.741	[18.8214]	0.739	[18.7706]
pring Load						
@ 2.055 in.	16.4 lb.		18.01 lb.		14.0 lb.	
[52.1970 mm]	[7.4390 kg]		[8.1693 kg]		[6.3504 kg]	

Cooling System Group

The cooling system group consists of the engine wa
pump, fan hub, thermostats, corrosion resistor,
coolers, radiator
other thermo-controls.

Water Pump—Unit 801

Supercharger-Driven Water Pump

Disassembly

1. Remove mounting capscrews, lockwashers, gasket (2, Fig. 8-1-1) and cover (1) from water pump body.
2. Pull drive coupling (10) from shaft (7).
3. Remove rubber washer (9).
4. Remove outer snap ring (8) from coupling end of pump body.
5. Support pump body on its mounting flange in arbor press and press bearing and shaft assembly (7) from impeller (3) and pump housing.
6. Remove carbon face seal (4) from pump body (6).

Cleaning

1. Clean all non-ferrous parts in Bendix carburetor cleane equivalent.
2. Immerse other parts in a solvent tank.
3. Make sure all traces of grease are removed.

Inspection

1. Inspect water pump bearing(s). Mark for replacement b ing(s) with rough or worn races.
2. Inspect water pump impeller. Mark for replacemer cracked or corroded to extent that it will interfere with

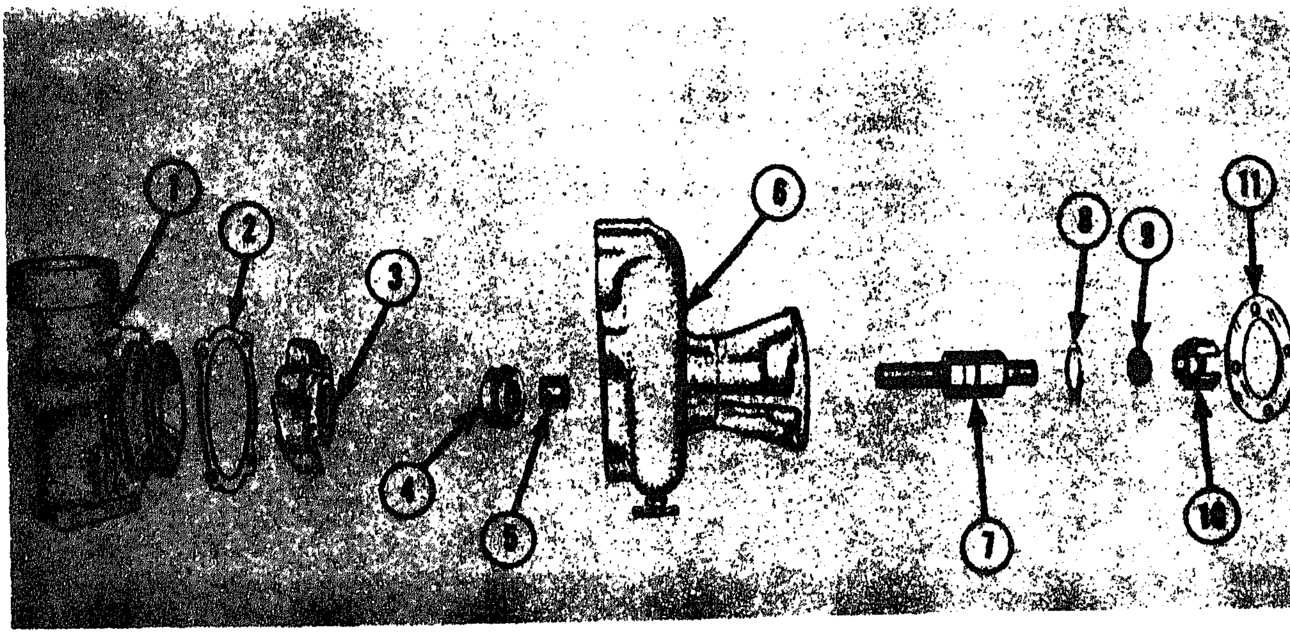


Fig. 8-1-1. Supercharger-driven water pump

ulation.

leasure impeller bore and shaft outer diameter. There must e a minimum of 0.001 in. [0.0254 mm] press-fit between haft and impeller; replace if necessary.

ispect water pump body seal face. Mark for refacing if ough or scored.

ispect water pump mounting parts for cracks. Replace as ecessary.

xamine carbon face seal carefully to make sure it is not racked or chipped, Fig. 8-1-2. Usually it is best to install new seal.

ispect ceramic seat; if damaged, mark it for replacement impeller is acceptable for ceramic seat replacement.

eplacing Ceramic Seal

trike damaged ceramic seat with a sharp tool perpendic-lar to axis of impeller.

crape adhesive from counterbore; do not damage counter-ore surface.

heck counterbore of impeller. It must be 1.042/1.046 in. 26.4668/26.5684 mm] diameter and square to the axis of 624/0.625 in. [15.8496/15.8750 mm] bore and within 0.003 in. .0762 mm] total indicator runout.

/ash and de-grease impeller in an approved cleaning sol-ent and air dry. The bore must be chemically clean to in-ure a good strong water-tight bond.

pply Bonding Film in counterbore. Care must be used to revent contamination of film by dust, dirt, oil, moisture or nger prints or use of film more than six months old.

emove bonding film liner, it may be necessary to pick ner to start separation.

ace ceramic seat in counterbore with identification mark limple) against adhesive. Rotate seat to insure a contin-ous bond.

pply a 15-lb. [6.8040-kg] weight on ceramic seat and place ssembly in temperature-controlled oven at 345°/355° F. 73.9/179.45° C.] for 65 minutes.

ote: The temperature and time must be closely controlled obtain proper bond.

heck ceramic seat, after curing, for squareness to the is of the 0.624/0.625 in. [15.8496/15.8750 mm] bore. It must within 0.004 in. [0.1016 mm] total indicator reading. heck for scratches, holes, chips or cracks. All unusable rts must be discarded and usable assemblies protected ainst further damage.

ssembly

ipport pump body (6, Fig. 8-1-1) on its cover mounting face and press bearing and shaft assembly (7) in place.

2. Install snap ring (8).
3. Install rubber washer (9).

Note: Current production water pump bodies are machined for beveled snap rings. Older models use flat snap rings. Use correct body and snap ring combination. Flat and beveled snap rings are not interchangeable.

4. Press drive coupling (10) on shaft flush with end of shaft.
5. Support pump on shaft; install slinger (5) over shaft until flange is 1.805/1.825 in. [45.8470/46.3550 mm] from impeller end of shaft.
6. Apply Plastic Lead Sealer #2 to bottom side of seal driving flange.
7. Press carbon face seal (4) in place; apply force on lip only (1, Fig. 8-1-5). Check carbon for damage befc ing further.

Note: Seals shown in Fig. 8-1-2 are interchangeable.

8. Clean seal with lint-free cloth to remove dirt, oil or grease.
9. Press impeller (3, Fig. 8-1-1) on shaft. Face of impeller hub should be 0.872/0.878 in. [22.1488/22.3012 mm] below cover mounting face on body (6).

Caution: Use extreme care when pressing impeller to prevent damaging ceramic seal.

10. Assemble lockwashers, capscrews and new gasket (2) to water pump cover (1).
11. Mount cover to pump body and turn shaft to be sure it is free.
12. Bearings are pre-greased. Do not lubricate.

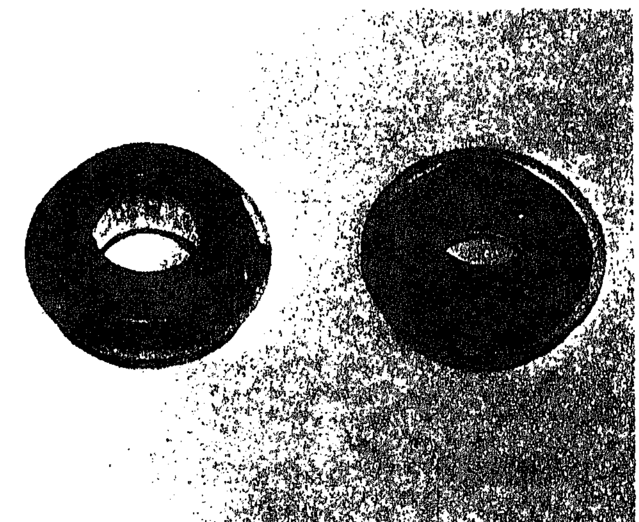


Fig. 8-1-2. Carbon face seals N10818

Fan Hubs—Unit 802

Eccentric Fan Hub

Disassembly

1. Remove capscrews and lockwashers from fan spacer (1, Fig. 8-2-2); remove spacer and discard gasket (2).
2. Remove cotter pin (3), nut (4) and washer (5) from shaft (12).
3. Press shaft from fan hub (8) with small end of shaft up.
4. Remove shaft (12) and locknut (13) from mounting bracket (14).
5. Press bearing (10) and oil seal (11) from spindle.
6. Discard oil seal.

Inspection

1. Clean all parts in an approved cleaning solvent and dry with compressed air.
2. Check shaft and bearings for scratches and wear.
3. Discard all fan hub parts that are worn or defective and replace.

Assembly

1. Press (do not drive) bearing race (7, 9, Fig. 8-2-2) into each end of fan hub (8) with cupped area outward. Bearing r must seat against shoulders provided inside hub.
2. Pack bearings (6, 10) with grease, working as much i the bearing as possible.
3. Place rear bearing (10) into bearing race (9).
4. Press oil seal (11) into hub. Coat oil seal lip with heavy
5. Press shaft (12) through oil seal and bearing.
6. Turn hub over and fill grease cavity with grease 60% 70% full. See grease specifications in Group 16.
7. Press front bearing (6) on shaft, being careful not to too much pressure.
8. Install flat washer (5) and slotted nut (4).

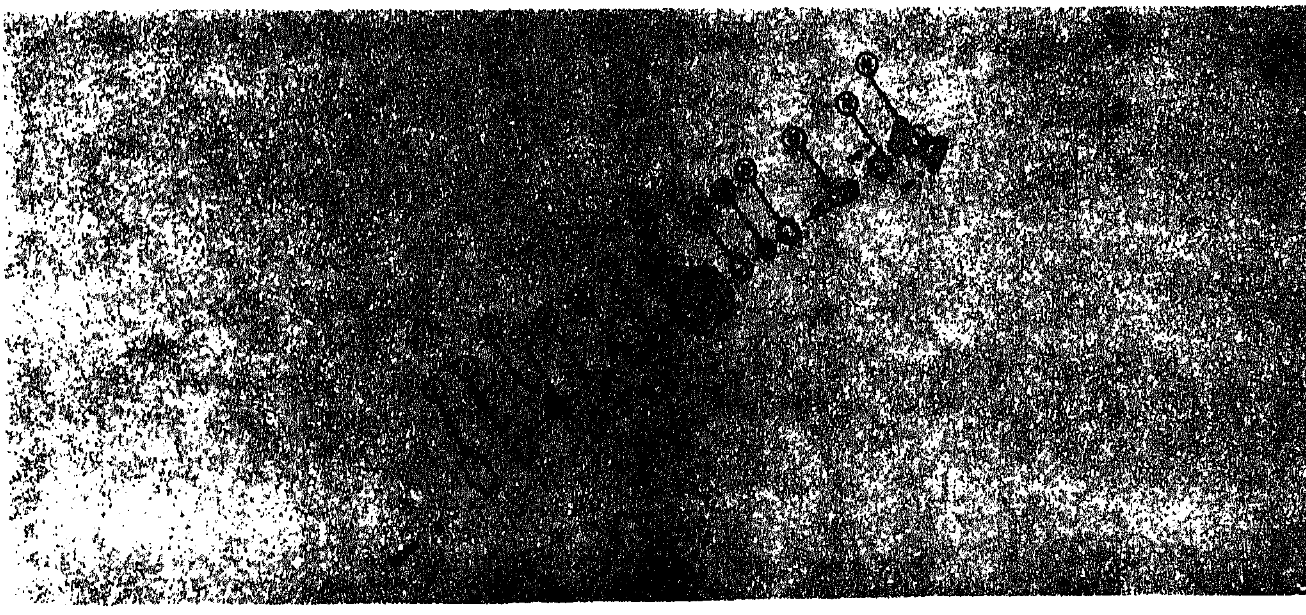
a. Tighten castellated nut until slight bearing drag can noticed as fan hub is being rotated.

Caution: Hub must be rotated while tightening. Failure do so will result in excessive end play.

b. Loosen nut one hex or one castellation; insert cotter (3) and bend ends over.

9. Assemble gasket (2) and fan spacer (1) to fan hub v capscrews and lockwashers.
10. Assemble locking nut (13) to shaft, and shaft (12) to mou ing bracket (14).

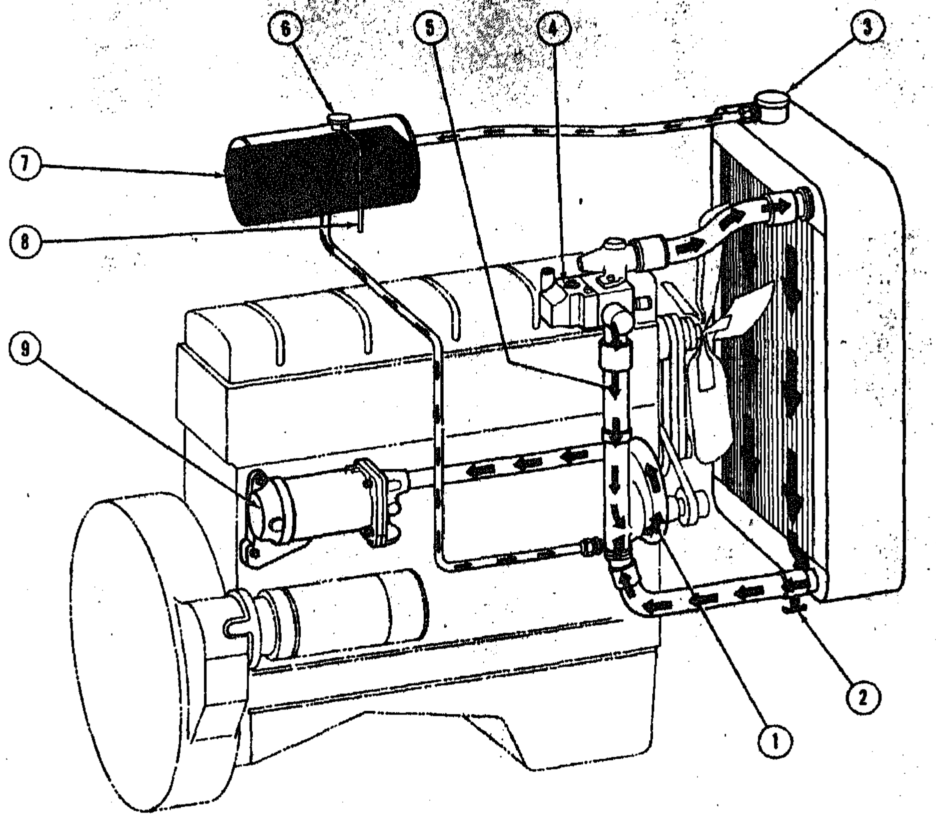
Caution: After lubricating fan hub, replace both pipe plug Use of fittings will allow grease to be thrown out, due rotative speed.



Radiator—Unit 807

Disassembly

1. To remove core sections with headers, it will be necessary to remove the front screen guard and front screen guard spacers.
2. Remove bolts holding core section header casting to top and bottom tank. Then each core section may be removed from front of radiator assembly.
3. If it is necessary to service any other part of radiator assembly, remainder of assembly may be removed from unit without danger of damage to core.
4. The fan screen guard is disassembled by removing sc attaching it to fan shroud.
5. Remove bolts holding fan shroud to side members to assemble fan shroud.
6. Overflow tube is removed by removing fitting in bo of top tank and clips holding it to side member, then ing it out of bottom of top tank.
7. Remove side members from top and bottom tanks, pleting disassembly operation.



1 WATER PUMP
2 DRAIN
3 SOLID CAP
4 THERMOSTAT HOUS
5 BY-PASS
6 PRESSURE CAP
7 SURGE TANK
8 OVERFLOW
9 OIL COOLER

Fig. 8-7-1. Coolant flow

Inspection and Rebuilding

Inspect radiator core for stoppage or leaks in same manner as described for the oil cooler (Group 7).

Do not use anti-leak compounds to stop core leaks. If split seams or solder breaks are found, have radiator repaired at qualified radiator repair shop.

To reassemble radiator, reverse disassembly procedure.

Caps

Radiator selection is normally based on a non-pressurized system; however, a pressure cap or valve set at approximately 4 to 7 psi [0.28124 to 0.49217 kg/sq cm] should be used, Table 8-7-1.

Caution: Before using higher pressure settings on cap, check radiator manufacturer.

Table 8-7-1: Radiator Caps

Part Number	Opening Pressure
69497	4 Psi [0.2812 kg/sq cm]
103624	4 Psi [0.2812 kg/sq cm]
119665	7 Psi [0.4922 kg/sq cm]

Hose

Hose must be able to withstand maximum pressure of system and at least 3 in. Hg [.10359 kg/sq cm] suction vacuum.

Use hose conforming to SAE 20R1 Standards.

Operating Temperature

The cooling system should be designed and the necessary controls used to maintain engine coolant outlet temperature, at the radiator top tank, between 170° F. [76.7° C.] and 190° F. [87.8° C.] during normal operation. Under no operating condition should temperature be above 200° F. [93.3° C.] and for best operation do not allow temperature to drop below 160° F. [71.1° C.].

Water Temperature Gauge

1. The sensing unit of the water temperature gauge (1, Fig. 8-8-1) must be located on engine side of thermostat so bulb is in water flow.
2. Warning light switches should not be set higher than 200°F. [93.3° C.] and the sensing bulb located as described for the gauge bulb.

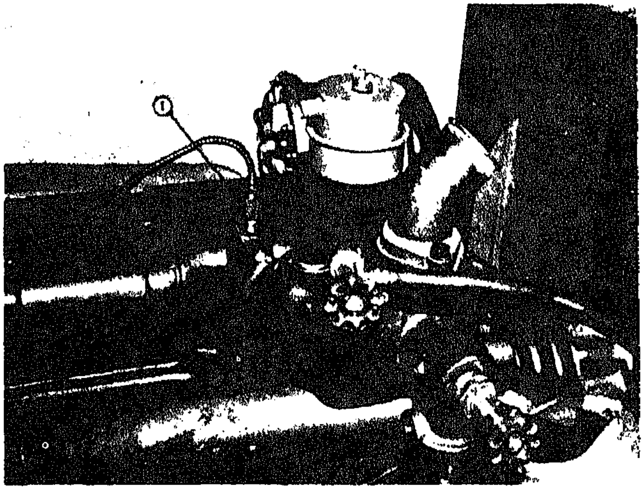


Fig. 8-8-1. Temperature gauge bulb location N20821

Drive Unit Group

The drive unit is used to transmit power from the eng crankshaft, through the camshaft gear, to drive a compr sor, fuel pump, water pump or other assemblies. Usua repair consists of replacement of oil seals, bearings bushings only.

Fuel Pump Drive—Unit 901

Ball Bearings

Since ball bearings are so extensively used in drive units, it is well to review some of the general rules concerning their use and handling.

1. Ball bearings should be installed or removed from housing with an arbor press, using the right size and type of mandrel or plate. Pressing should be done on the race that is press fit. When the bearing is being pressed into a housing, the force should always be applied to the outer ring.
2. Work with clean tools in clean surroundings.
3. Remove all outside dirt from housing before exposing bearings.
4. Handle with clean, dry hands.
5. Treat a used bearing as carefully as a new one.
6. Use clean solvents and flushing oils.
7. Lay bearings out on clean paper.
8. Protect disassembled bearings from dirt and moisture.
9. Wipe bearings with clean, lint-free cloth.
10. Keep bearings wrapped in oil-proof paper when not in use.
11. Clean inside of housing before replacing bearings.
12. Install new bearings as removed from the packing, without washing.
13. Keep bearing lubricants clean when applying and in covered containers when not in use.
14. Pack used and washed bearings with ball bearing grease before installation.
15. Do not take new bearings apart (unless two-piece assembly where each part is installed separately).
16. Never press against separators.
17. Never pound on a bearing or race.
18. Do not spin bearings before cleaning. Do not spin by force of air. Hold both races while drying with clean, compres air.
19. The following types of defects cause bearings to be jected for further use:

a. Broken or cracked race.

b. Dented shields or seals.

c. Cracked or broken separators.

d. Flaked areas on balls, rollers or raceways.

e. Broken or cracked balls or rollers.

f. Bearings that have been overheated. These bearings generally darkened to a brownish-blue or blue-black c

g. Bearings whose raceways are indented or "brinelled" impressing balls or rollers into the races.

20. Dirt causes ball bearings to fail.

Oil Seals

1. When an oil seal fails it is useless.
2. Oil seals are easily ruined by allowing shaft to turn ag the sealing lip during installation, or by leaving key shaft.
3. The sealing lip must always compress with pressure.
4. The effectiveness of the seal depends on surface w seal seats. Always check hub sleeve surface for wear replace sleeve if necessary before installing new seal
5. Immediately before installing seals, always lubricate clean SAE 30 lubricating oil.

Bores In Housing

1. Ball bearings must not turn in housing retaining bore.

aring has turned and ruined housing, both bearing and using must be scrapped.

ore of housing must be clean before pressing bearing in ace.

rust Washers

installation of thrust washers on accessory drives, the ust side of washers are to be installed away from housj. The thrust side is identified by grooves. The steel cking against the cast iron housing will reduce the posbility of the thrust washer's turning.

proper installation of these washers will result in excese wear and increased end play, which causes early faile of the accessory drive assembly.

el Pump and Compressor Drive

Disassembly

1. Remove drive shaft capscrew (12, Fig. 9-1-2); using suitable puller, pull coupling (10) from shaft.

2.

Note: On IOL engines, remove clamping washer (9, Fig. 9-1-2) and thrust washer (8).

3. Press shaft from gear (1).

4. Remove keys (2, 3) from shaft (4).

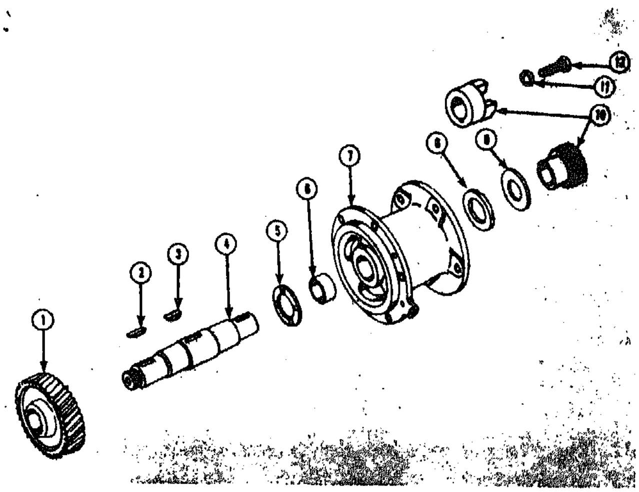


Fig. 9-1-2. Fuel pump drive (IOL) N20905

Inspection

1. On IOL engines, inspect bushing (6, Fig. 9-1-2) in drive support (7). Replace if worn larger than 1.322 in. [33.5788 mm] or if more than 0.002 in. [0.0508 mm] out-of-round. New dimensions are 1.314 to 1.319 in. [33.3756 to 33.5026 mm] in diameter. Available for service only are undersize bushings to compensate for wear; 0.010 in. [0.2540 mm] undersize dimensions are 1.304 to 1.309 in. [33.1216 to 33.2486 mm], 0.020 in. [0.5080 mm] undersize dimensions are 1.294 to 1.299 in. [32.8676 to 32.9946 mm].

3. Replace thrust washers (5, 8) if worn or damaged.

4. Inspect gear (1) and coupling (10) for chipped, cracked or worn teeth.

5. Check shaft (4) for wear, damaged keyways or damaged threads. New dimensions for the bushing surface of shaft are 1.3115 to 1.312 in. [33.3111 to 33.3248 mm]. Replace if defective or worn smaller than 1.310 in. [33.2740 mm].

Assembly

1. Install key (3, Fig. 9-1-2) in shaft (4) and press on gear to 1.143 to 1.145 in. [29.0322 to 29.0830 mm] in direction shown by arrows (1, Fig. 9-1-3).

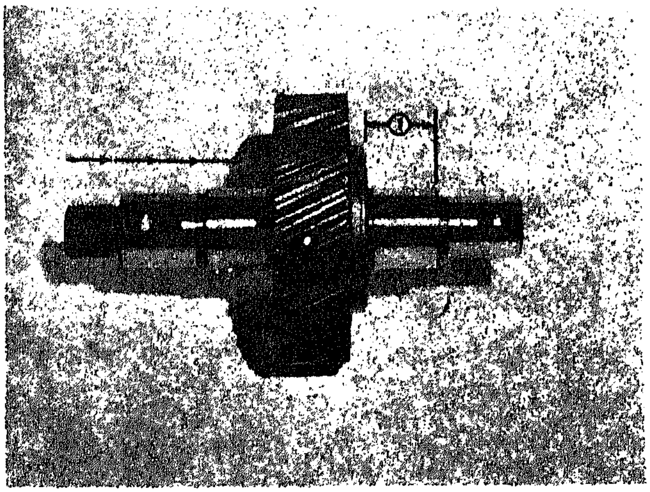


Fig. 9-1-3. Accessory drive assembly dimension N20907

2. Place thrust washer (5, Fig. 9-1-2) on shaft against gear (1) (except EOL).

3. Press bushing (6) in support (7) if removed on IOL engines

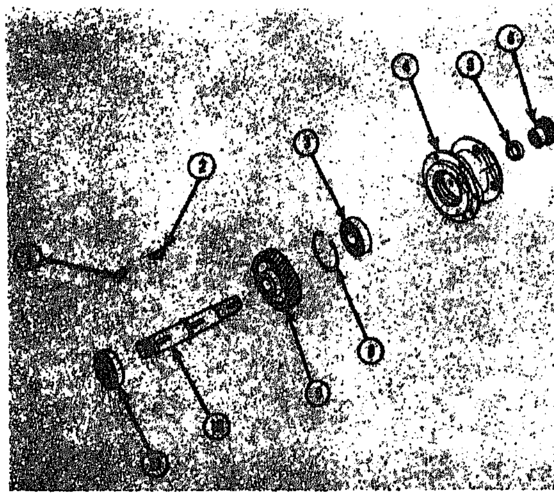


Fig. 9-1-4. Fuel pump drive (EOL)

4. Place shaft (4, Fig. 9-1-2) and gear (1) assembly port (7).

5. Install second thrust washer (8) and flat washer (9) in support.

6. Place coupling key in shaft and press coupling shaft.

Note: Some drives use Lovejoy-type couplings w assembled to shaft with capscrew (12).

7. Install capscrew and lo (12, Fig. 9-1-2).

8. Check end clearance. It should be 0.004 to 0.012 i to 0.3048 mm].

Supercharger—Unit 1004

Preliminary Inspection

Before disassembling supercharger, the following inspection procedures must be observed.

1. Check for excessive oil at air outlet port indicating broken piston ring oil seals.
2. Check radial clearance in bearings:
   a. Remove pump end cover and force fuel oil through oil inlet to flush all lubricating oil from bearings.
   b. Install an indicator gauge on rotor timing gear outer diameter. Fig. 10-4-1.

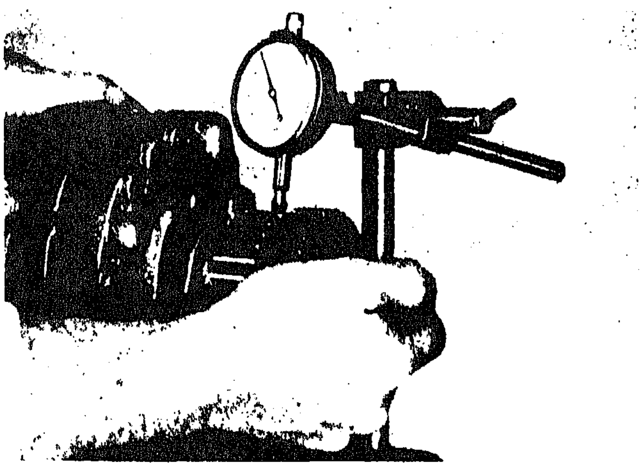


Fig. 10-4-1. Check radial bearing clearance N21003

   c. Check total radial movement by moving gear from side to side. If movement exceeds 0.003 in. [0.0762 mm], disassemble unit for a complete bearing inspection.
3. Check rotor shaft end play. Fig. 10-4-2.
   a. Install a dial indicator at end of rotor shaft.
   b. Push shaft back and forth; note indicator reading.
   c. If total end play exceeds 0.005 in. [0.1270 mm], disassemble supercharger and inspect thrust faces.
   d. Perform this operation on both rotor shafts.

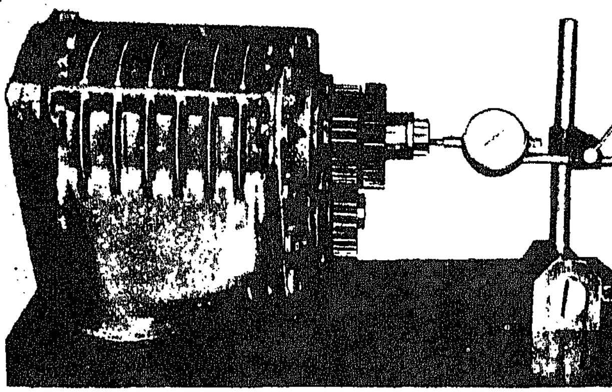


Fig. 10-4-2. Checking end play N21

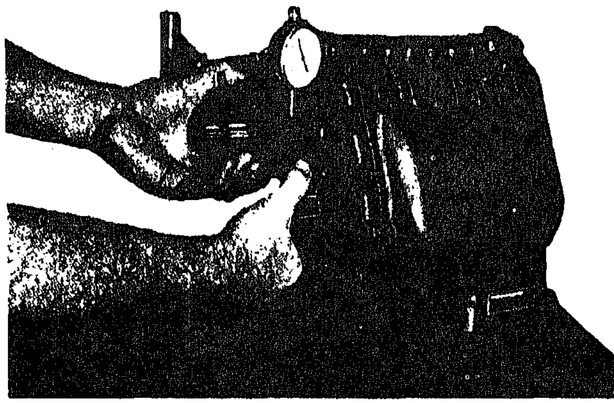
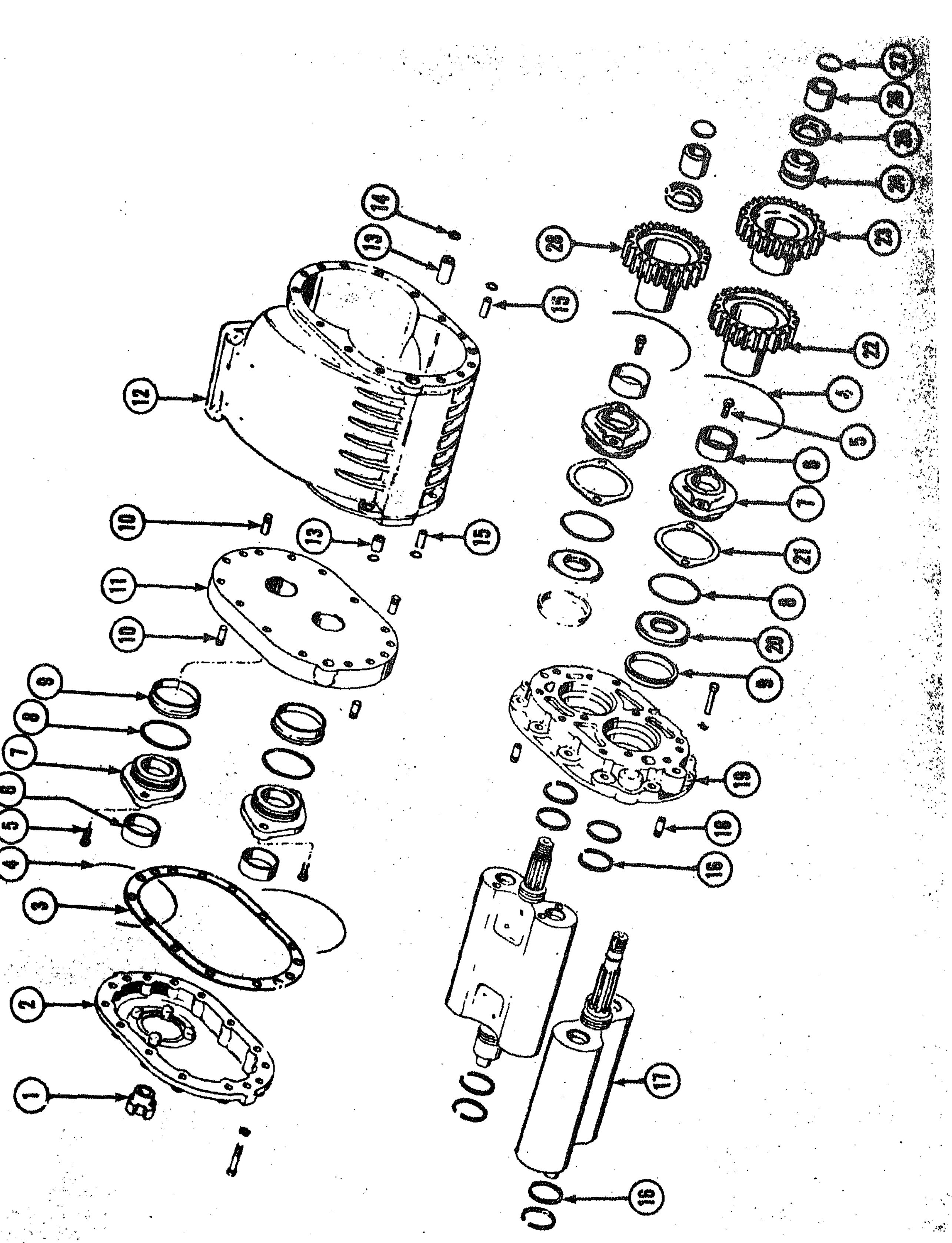


Fig. 10-4-3. Checking gear backlash N21

   a. Install an indicator gauge to supercharger housing a check rotor timing gear backlash.
   b. If backlash exceeds 0.004 in. [0.1016 mm], a new set gears must be installed.
5. Insert a feeler gauge in inlet port between housing a rotor lobe. Minimum clearance is 0.005 in. [0.1270 mm].
6. Check clearance between rotor lobes through the air i



N21002

Fig. 10-4-4. Supercharger — exploded view

If preliminary inspection does not indicate any of the above wear conditions, supercharger may be reinstalled on the engine.

Note: Use a new gasket when replacing pump end cover. If one or more of the preceding wear conditions are noted, disassemble supercharger for a complete inspection or return to factory for a complete rebuild.

Disassembly

See Fig. 10-4-4 and/or Fig. 10-4-5 for reference numbers.

1. Raise lockwasher flange clear of slot in the shaft nut and remove shaft nut with a shaft nut wrench. Fig. 10-4-6.

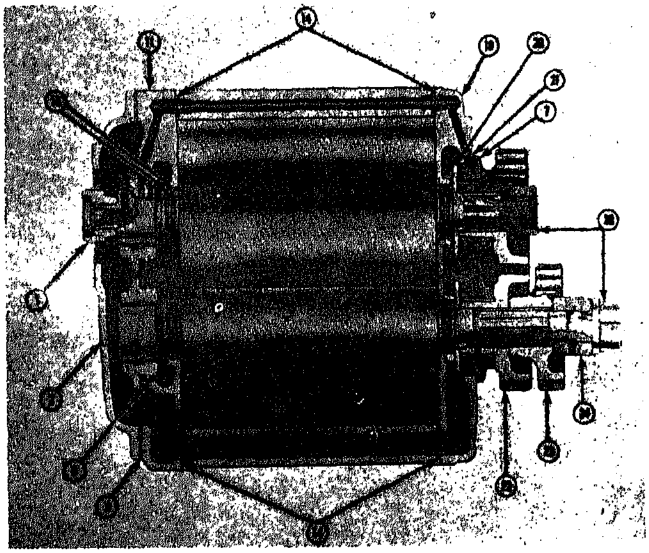


Fig. 10-4-5. Supercharger — cross section N21004

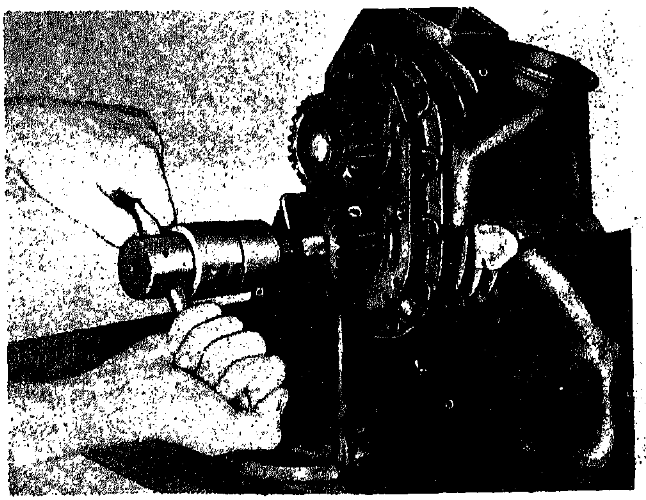


Fig. 10-4-6. Removing rotor shaft locknuts N21007

2. Wedge a piece of soft metal between timing gear teeth lock gears while loosening shaft nuts.
3. Remove shaft nut (26, Fig. 10-4-4) (Fig. 10-4-5) and lo washers (25) from rotor shafts and slide outboard jour (24) from drive rotor shaft (17). Remove expansion plug damaged.
4. Pull water pump coupling half (1) from driven rotor sh with a gear puller.
5. Remove capscrews and lockwashers securing end co (2) and gasket (3). Discard gasket. Tap cover with a rub mallet to loosen from housing dowels (10).
6. Remove capscrews and lockwires securing bearing ca (7) to end plate (11). Remove bearing cages by rotat and prying.
7. Remove bearing cage seal rings (8) and press bearings from bearing cages. Mark bearing cages to assure repla ment in identical position from which removed.
8. If damaged, pry oil collector rings (9) from end plate and remove dowels from end plate.
9. Remove capscrews from front end plate (19) and rem end plate and rotor assembly from housing (12).
10. Remove oil pressure ferrules (15) and "O" rings (14).
11. Press drive gear (23) and timing gears (22 and 28) f rotors and end plate assembly and extract rotors from plate assembly. See Fig. 10-4-7 for pressing gears off rot

    Note: The rotors must be rotated into position so lob rotor being pressed out does not catch on the shaf other rotor.

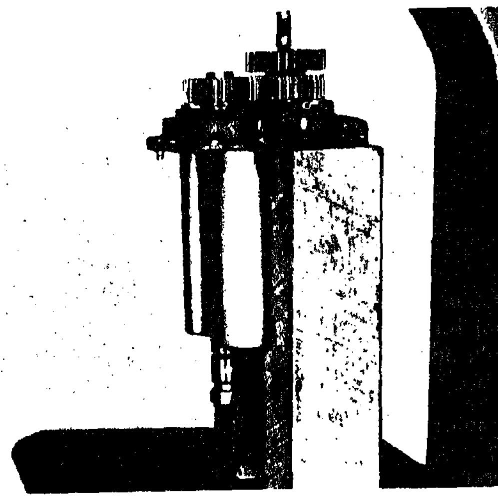


Fig. 10-4-7. Pressing gears of rotors

12. Remove lockwires and capscrews securing bearing c (7) to the gear end plate (19).

pry them free. Remove shims (21) and bearing cage seal rings (8) from bearing cages and press out bearings (6). Mark bearing cages to assure identical replacement.

Remove thrust washers (20) from the gear end plate.

Remove oil collector rings (9) and dowels (18), if damaged.

Remove and discard all shaft seal rings (16).

Inspection

Clean all parts in approved cleaning solvent.

Check housing for cracks, nicks, obstructed oil passages and stripped threads. Repair damaged threads. Remove nicks or scratches with a handstone. Be sure all mating surfaces are smooth. If housing is damaged or worn extensively, discard.

. Inspect rotors for undue wear, burrs, pits, scratches or other damage. Check threaded ends, shoulders, spline bearing surfaces and seal ring grooves for wear. Small burrs and imperfections on rotor lobes can be dressed down with a handstone. If lobe surfaces or rotor shafts are badly scored or damaged, discard rotor set.

Inspect timing gears, drive gear and all gear hubs for cracks and broken or worn teeth, damaged splines and excessive wear.

Note: Damaged or worn rotors must be replaced in pairs. Timing gears must also be replaced in pairs.

. Examine end plates for cracks or damaged seal ring bores. Check for snug dowel fits. Excessive wear and roughness in the seal ring bores will not allow the seal rings to seat properly; thus end plates must be discarded and replaced with new parts.

. Check end cover for cracks. End cover must have a smooth mating surface.

. Inspect bearing cages for cracks or excessive wear. Discard defective bearing cages. Bearing cage assemblies are also available in 0.010 and 0.020 in. [0.2540 and 0.5080 mm] undersize.

. Inspect bearings for scratches or scoring. Check bearing bores with inside micrometers. If bore exceeds 1.3765 in. [34.9631 mm], discard bearings.

. Examine thrust washers for burrs, cracks and wear. Discard damaged or worn thrust washers.

. Check outboard bearing journal for nicks, scoring or excessive wear.

. Inspect water pump drive coupling half for excessive wear.

. Check end thrust by measuring bearing cage width and distance from thrust face of gear to end of gear hub. Bear-

mm] less than length of gear hub. Figs. 10-4-8 and 10-4-9. If difference between Fig. 10-4-8 and Fig. 10-4-9 dimensions is greater than 0.005 in. [0.1270mm], install new gears, thrust washers and bearing cages.

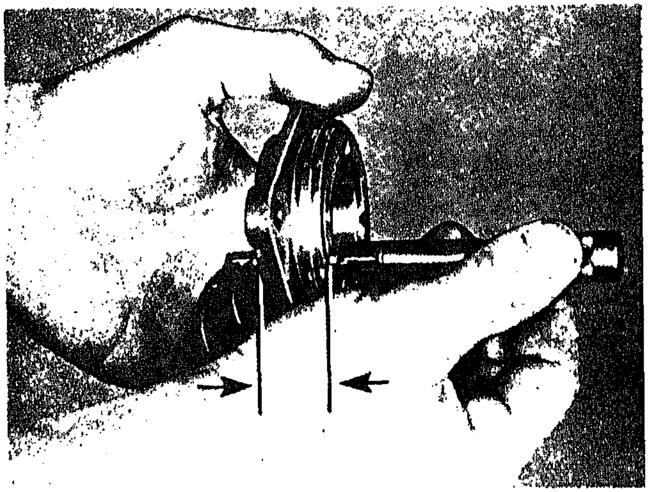


Fig. 10-4-8. Che bearing cage width N21009

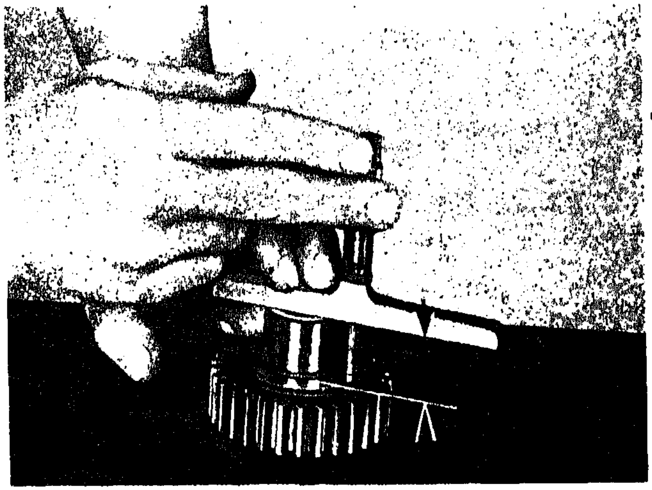


Fig. 10-4-9. Checking gear hub length N21010

Assembly

1. Use new shaft nut lockwashers (25, Fig. 10-4-4), expansion plugs (27), seal rings (8), oil collector rings (9) and gaskets (3) in assembly.
2. Install new shaft seal rings (16) on rotors.
3. Install new bearing cage seal rings (8) on bearing cages (7).

4. Press bearings (6) into bearing cages and oil collector rings (9) into end plates. Press in new end plate dowels (10), if removed.

5. Install oil pressure ferrules (15), drain ferrules and ferrule seal rings (14) in housing (12).

6. Position thrust washers (20), shims (21) and bearing cages (7) into gear end plate (19); secure with capscrews and lockwires (4).

   Note: If old bearing cages are reused, replace in same hole from which removed. Use same shims as originally removed from respective cages. Use 0.005 in. [0.1270 mm] total shim thickness under each bearing cage. Shim thickness may have to be adjusted when rotor end clearance is checked.

7. Press water pump coupling (1) on driven rotor shaft extension so that shaft end is flush with water pump coupling counterbore.

8. Lubricate gear end plate seal ring seats and bearings with clean, light engine oil and insert splined shaft end of driven rotor in the bottom hole in gear end plate.

   Note: Do not damage seal rings while pressing into gear end plate (19).

9. Position timing gear (22) on drive rotor shaft and press into position.

10. Insert driven rotor shaft through the second hole in gear end plate (19) and press on timing gear (28) making sure rotors are positioned exactly 90° apart as timing gears mesh. Fig. 10-4-10.

11. Press drive gear (23, Fig. 10-4-4) on drive rotor shaft snugly against timing gear and install outboard bearing journal (24) on drive rotor shaft.

12. Install shaft nut lockwashers (25) and shaft nuts (26) on rotor shaft and tighten securely. Wedge a piece o metal between gear teeth to lock gears while tigh locknuts.

13. Position expansion plugs (27) on locknuts and ta place.

14. Push rotors toward gear end plate and check end ance. Fig. 10-4-11. End clearance should be 0.003 to in. [0.762 to 0.1016 mm]. Add or remove shims under ing cage mounting flange to obtain correct end clea If shims must be changed, remove locknuts and ge described in disassembly instructions.

15. Install oil pressure ferrules (15, Fig. 10-4-4) and "O" (14). Lubricate with light oil. Position housing (12 rotors against end plate (19) and secure with lockw and capscrews.

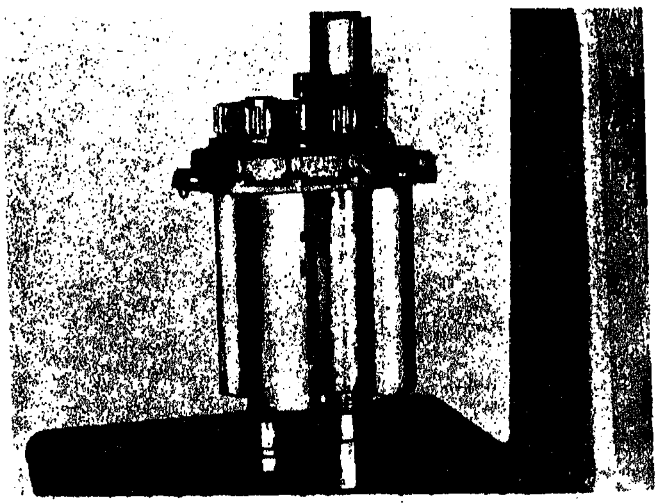


Fig. 10-4-10. Pressing gears on rotors N21011

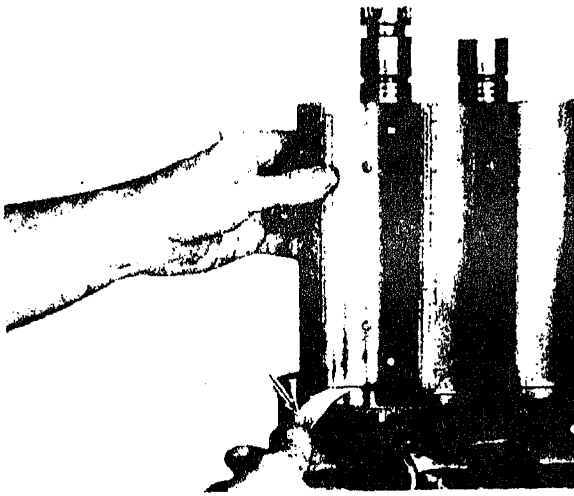


Fig. 10-4-11. Checking rotor end clearance

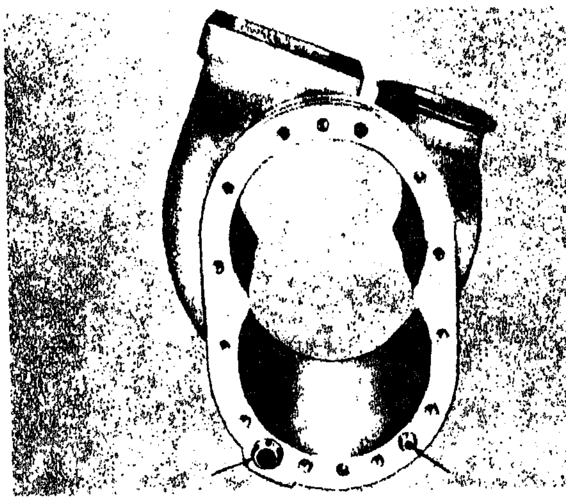


Fig. 10-4-12. Oil seal rings

Table 10-1: Supercharger Assembly Dimensions — In. [mm]

Part Name	New Minimum	New Maximum	Worn Limit
Radial Bearing Clearance			0.003 [0.0762]
Gear Backlash			0.004 [0.1016]
Rotor Shaft End Play	0.003 [0.0762]	0.004 [0.1016]	0.005 [0.1270]
Gear Hub Protrusion	0.002 [0.0508]	0.005 [0.1270]	0.005 [0.1270]
Rotor To Rotor Clearance	0.006 [0.1524]		
Rotor To Housing Clearance	0.005 [0.1270]		
Rotor To Gear Plate	0.003 [0.0762]	0.004 [0.1016]	
Rotor Shaft Bushing			1.3765 [34.9631]

Lubricate bearings (6) and seal rings (8) in end plate (11) and position end plate to housing (12). Do not damage shaft seal rings. Tap into place.

Position end cover (2) and new gasket (3) to end plate; secure with lockwashers, capscrews and lockwires.

Turn drive gear by hand to check for smooth, free operation.

Exhaust System Group

The exhaust system group consists of engine exhaust ma-
ifolds, piping and mufflers or silencers.

Manifolds—Unit 1101

Exhaust Manifold (Dry Type)

Cleaning and Inspection

1. Steam clean manifold.
2. Inspect exhaust manifold for cracks and distortions; discard defective parts.
3. When ordering replacement parts, order same part as presently used. Manifolds are made of different materials and the rate of expansion may cause cracking if incorrect manifold combinations are used.

Air Equipment Group

The air equipment group consists of Cummins air com
sors, check valve, and piping.

Introduction

Air Compressors — Operation

The air compressor is driven from a gear in the gear train
flange mounted direct to gear case,

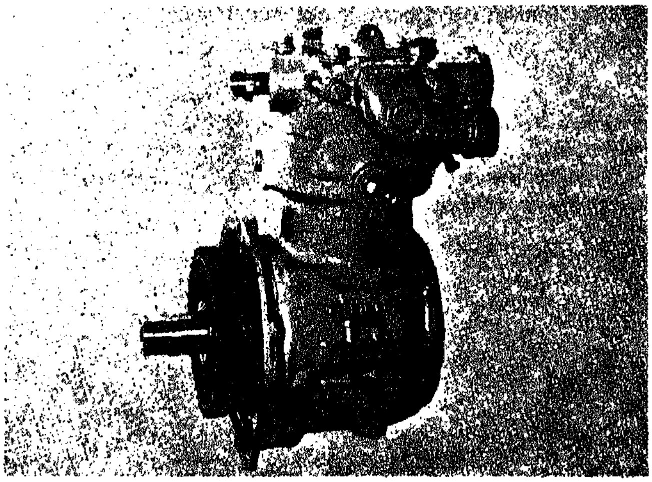


Fig. 12-1-1. Cummins compressor N11206

The air compressor operates continuously while the engine is running. Actual air compression, however, is controlled by the air governor. Acting in conjunction with the unloader valve in the compressor cylinder head, the governor starts or stops the compression of air by loading or unloading the compressor when the air reservoir pressure reaches a pre-

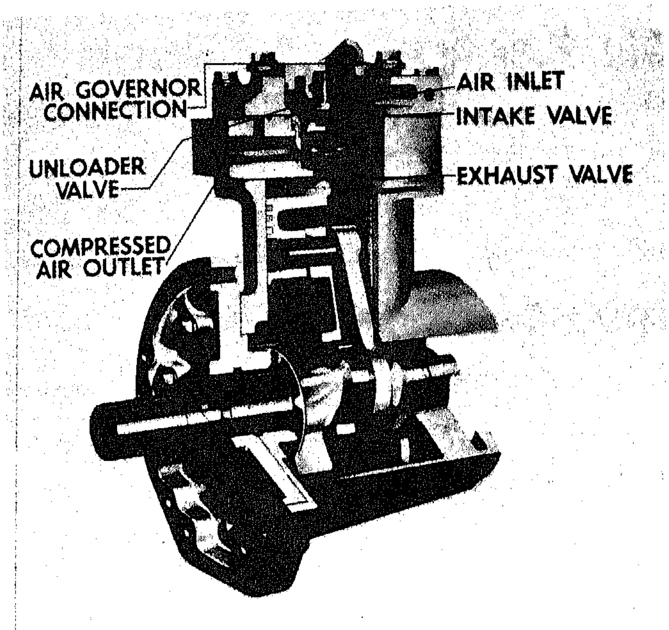
are of the compact compressor; however, the same
ciples apply.

Air Intake

As the piston moves downward on the intake stroke
tial vacuum occurs above the piston. The differen
cylinder pressure and atmospheric pressure forces the
valve down from its seat, allowing air to flow throug
intake port into the cylinder. When the piston has re
the bottom of its stroke, spring pressure is sufficie
overcome the lesser pressure differential and force
valve against its seat.

Compression

When the piston starts its upward stroke, the incr
pressure of the air in the cylinder and head force
outlet valve away from its seat. The compressed ai
flows through the outlet ports and into the air tank
piston continues its upward stroke. When the
reaches the top of its stroke, the air pressure in the



DOUBLE BEARING

N11208

ainst its seat and closes off the outlet passage.

lloading

hen pressure in the air tank is at a predetermined level, pressure is applied to the top of the unloader cap by a mpressor governor. This pressure forces the cap down d seals off the intake passage. Pressure in the delivery ssage holds the exhaust valve in closed position. When essure in the air tank drops, the cap returns to its upper sition and the intake and compression sequences repeat.

ibrication

ne compressor is lubricated by the engine lubricating oil. ternal oil lines are used.

il enters the compressor through a drilling in the front of e support

Oil entering ese passages lubricates the connecting rod bearings and ankshaft. The oil then flows to the compressor crankcase d returns to the engine through the oil drain located next the oil inlet.

n oil supply metering device is used to reduce the quanty of oil to the compressor crankcase. The metering dece is installed into the compressor oil supply line in the ipport or crankshaft.

Cooling

Water from the engine cylinder block cools the compressor.

On the compact compressor, water enters the cylinder head only, the crankcase is cooled by air and lubricating oil. Flowing around the head, the water returns to the block through the water outlet port in the compressor cylinder head.

Air Check Valve

The purpose of a check valve is to prevent loss of reservoir air in the event of compressor or air line failure (between the compressor and the reservoir). Thus, the reservoir is full and has ample air in the system for several brake applications. The valve is mounted either in the air line connecting the compressor to the reservoir, see part 1, page 93a, item 8, for location of check valves.

The I.C.C. states that a means must be provided to prove the check valve operative. This is accomplished by installing a petcock in the air line between the compressor and the check valve.

When the petcock is opened, a check valve operating properly will not permit air to escape from the reservoir through the petcock; whereas, a malfunctioning valve will result in loss of reservoir air. Operation of the check valve should be inspected occasionally; if any evidence of malfunction is indicated, dismantle, thoroughly clean parts and reassemble.

Experience to date indicates that failure of air check valves has many times resulted in complaints against air compressor performance. The check valves have failed in three ways.

1. **Failed Open** — Allows air to enter reservoir but will not seal or seat should a line failure occur between check valve and compressor allowing complete system pressure loss. Will not pass I.C.C. inspection.
2. **Failed Closed** — Does not allow air to be pumped into reservoir resulting in extremely high compressor cylinder pressure and temperature. Line and valve carboning, line bursting, rod or crankshaft breakage are typical failures. These high pressures and temperatures will result in permanent damage to all valve parts and possible major component damage.
3. **Restricted Flow** — Allows some air to be pumped to the reservoir. General indication is long pump up time required. Restricted flow will result in higher than normal discharge pressures and temperatures. Cause line and valve carboning, and if not corrected promptly can cause "O" ring and spring damage. If allowed to progress will result in completely closed check valve.

Vacuum Pump — Operation

The vacuum pump is an adaption of the Cummins compact compressor, the similarity is apparent, see Fig. 12-1-2 and 12-1-5.

The Cummins "Compact" vacuum pump operates continuously while the engine is running.

Air Intake

As the piston moves downward on the intake stroke a vacuum occurs above the piston. The difference in cylin pressure and atmospheric pressure forces the inlet va from its seat allowing air to flow through the intake p into the cylinder from vacuum tank thus creating m vacuum in the vacuum tank. When the piston has reacl the bottom of its stroke, spring pressure is sufficient overcome the lesser pressure differential and forces valve against its seat. Fig. 12-1-6.

Air Discharge

When the piston starts its upward stroke, the increa pressure of the air in the cylinder and head forces the c let valve away from its seat. The air then flows through outlet port and is discharged into the vacuum pump cra case or the engine crankcase, as the piston continues upward stroke. When the piston reaches the end of stroke, the air pressure in the head drops to a point wh the spring forces the exhaust valve against its seat closes off the outlet passage. Fig. 12-1-6.

Cooling

Water from the engine cools the vacuum pump. Enter the head of the vacuum pump by external lines, the wa circulates through the cylinder head. After flowing thro the head, the water returns to engine cylinder head block. Fig. 12-1-6.

Lubrication

The vacuum pump is lubricated by engine lubricating Internal drillings or external oil lines are used, depend on which type the engine utilizes. Oil enters the vacu pump through an internal drilling in the support on engines. Oil entering these passages lubricates the c necting rod bearings, support bearings and crankshaft. oil then flows to the vacuum pump crankcase and retu to the engine through the oil drain. An oil supply meter

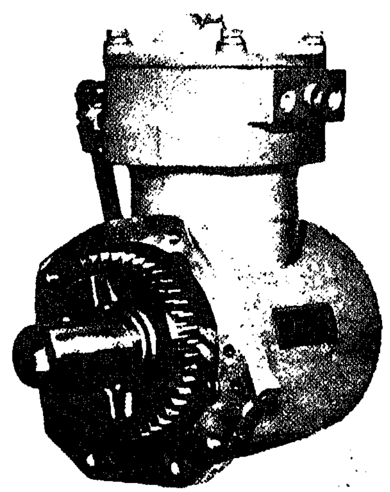


Fig. 12-1-5. Cummins vacuum pump

N1

Table 12-1-1: Compressor and Vacuum Pump Specifications

Data	Compressor
Air Delivery	12 CFM
Vacuum Pulled	——
Cylinders	1
Piston Displacement (Cu. In)	17.63
Bore (Inch)	3.4375
Stroke (Inch)	1.9
Speed	Engine Speed
Cooling	Engine Coolant
Lubrication	Engine Oil
Line Sizes	
Water inlet and outlet (O. D.) tubing (Inch)	1/2
Air inlet (O. D.) tubing (Inch)	1
Air outlet (O. D.) tubing (Inch)	5/8
Height (Inch) Overall (Approx.)	11-1/2
Width (Inch) Overall (Approx.)	7-1/2
Length (Inch) Overall (Approx.) (Varies, depending on support, crankshaft and drive)	7-1/2 to 11-3/8
Weight (Pounds) (Approx.) (Varies, depending on support, crankshaft and drive)	38 to 47

Air Equipment Group

Cummins Air Compressor Unit—1201

This section covers the Original Cummins 12 CFM air compressor.

Compressors are often serviced while on the engine since often a change of a cylinder head or parts therein is all that is required. For this reason the cylinder head is described first in the manual. However, if the compressor is removed from the engine it should first be mounted on ST-749 and ST-302 as described under "Crankcase and Support" following.

Cylinder Head

All cylinder heads used on Cummins air compressors are identical except the model used on V6-200 and V8-265 engines. These cylinder heads have the water and air line openings positioned slightly different from other models.

Disassembly

1. Loosen cylinder head capscrews and remove cylinder head from compressor crankcase. Discard gasket.
2. Remove air inlet connection and gasket.
3. Loosen capscrews and remove unloader valve assembly from cylinder head by prying loose with **two screwdrivers.** Fig. 12-2-1.
4. Remove "O" ring from unloader body.
5. Life unloader cap spring from intake valve seat and discard.
6. Remove unloader cap from unloader body.
7. Remove unloader cap guide and packing seal from inside unloader body. (Guide currently integral with body.)
8. Lift intake valve seat from cylinder head. Fig. 12-2-2. Turn with large screwdriver to loosen.
9. Remove intake valve and spring from cylinder head.
10. Press exhaust valve assembly from underside of head with thumb pressure. If stuck use wooden driver.

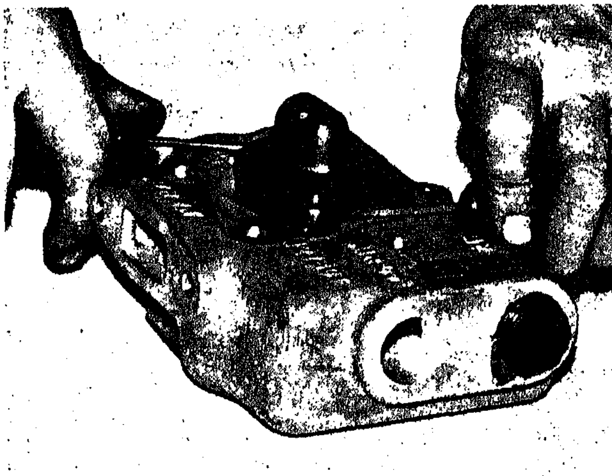


Fig. 12-2-1. Remove unloader valve assembly N112

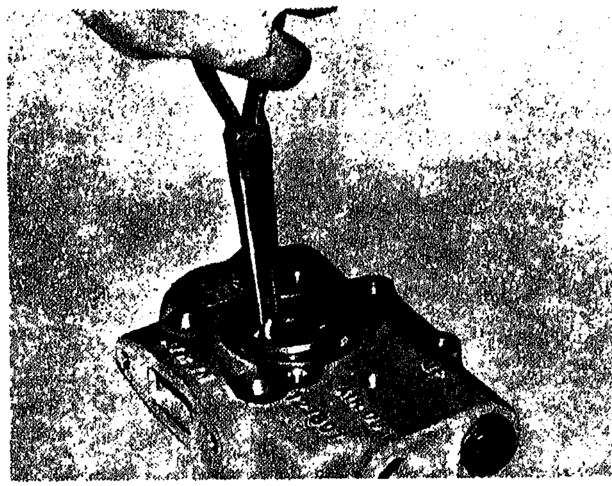


Fig. 12-2-2. Remove intake valve seat N11

Remove "O" rings from exhaust valve seat.

Pull exhaust valve from exhaust valve seat.

Cleaning

Immerse cylinder head in cleaning solvent that is not harmful to aluminum. Remove all carbon from valve and air discharge cavities as well as rust and scale from water cavities. Use compressed air to blow dirt from all cavities. Use dental mirror to inspect. A head not completely free of carbon in the air passage will experience valve carboning again very quickly. Fig. 12-2-3.

Inspection

Check for visible cracks or breaks in the cylinder heads.

Check for water leakage.

Assemble cylinder head to crankcase using new gasket.

Plug the water outlet and apply water under pressure through water inlet.

Check for leaks. Discard parts as necessary.

Check exhaust valve seat height. If height is less than .485 in., discard seat. Fig. 12-2-4.

Check intake valve seat height. If height is less than .270 in. it cannot be salvaged and must be replaced new. Fig. 12-2-5.

Apply bluing to exhaust and intake valve seating surfaces to check seats. If seating surfaces are not 100% true they may be lapped. If lapping will lessen valve seat height beyond wear limit, discard valve assembly.

If lapping is necessary to acquire a good exhaust valve seat:

Apply bluing to surface of exhaust valve to be lapped and allow to dry.

Apply lapping compound (half 38-900A and A-600) to exhaust valve and place valve on seat.

Insert exhaust valve seat in lapping block. Fig. 12-2-6.

Using a standard hand valve lapper and rubber suction cup; lap valve till a good seat is acquired. Add additional lapping compound as necessary.

Valve must be flat within .001 inch total indicator reading.

To lap intake valve:

Install rubber buffer in top of exhaust valve seat.

Apply bluing to intake valve. Allow to dry.

Apply lapping compound to intake valve. Place intake valve seat on intake valve and lap until a good seat is acquired. Valve must be flat within .001 inch total indicator reading.

Check upper part of unloader cap where packing seal seats for scoring or excessive wear.

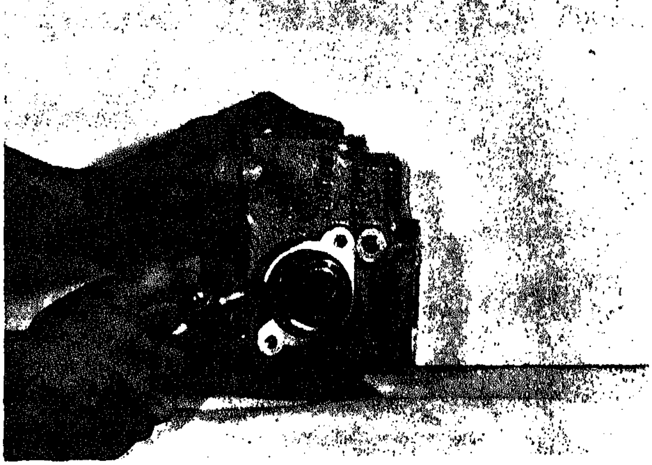


Fig. 12-2-3. Blow dirt from cylinder head N11214

8. Check seating area of unloader cap for distortion, pitting or wear.

9. Replace new unloader cap spring at each rebuild.

Assembly

1. Place exhaust valve on exhaust valve seat. Lubriplate "O" ring and install on exhaust valve seat.

2. Install exhaust valve spring in cylinder head then place exhaust valve assembly atop spring.

3. Install intake valve spring and place intake valve then intake valve seat atop spring.

4. Install packing seal and unloader cap guide in unloader valve housing.

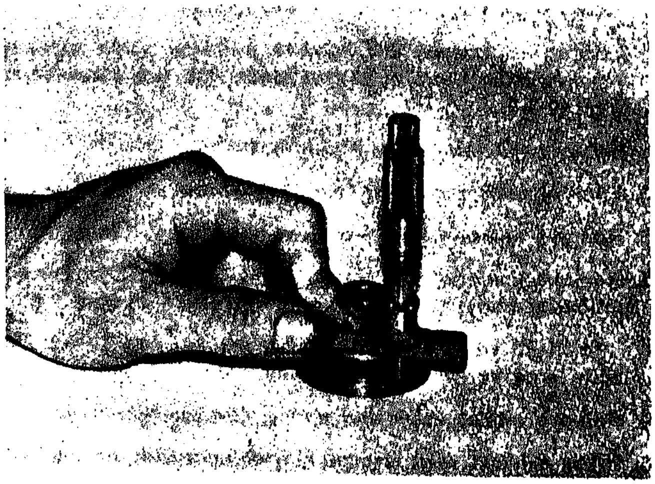


Fig. 12-2-4. Check exhaust valve seat height N11215

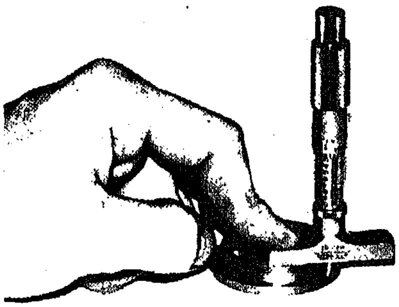


Fig. 12-2-5. Check intake valve seat height N11216

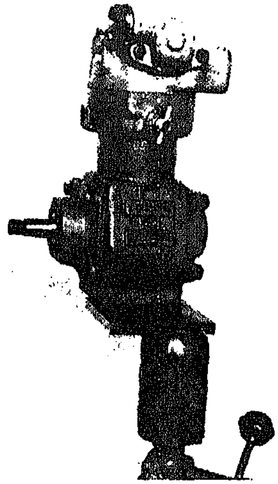


Fig. 12-2-7. Mount compressor on ST-749 and ST-302 N1121

5. Lubricate and install "O" ring on unloader valve housing.
6. Lubricate and install unloader cap in unloader cap guide.
7. Install unloader valve spring in unloader cap.
8. Install unloader valve assembly in head. Install and tighten hold-down capscrews.

Crankcase and Support

Disassembly — Gear Driven Compressor

After removing compressor and support from engine, mount unit to mounting plate, ST-749 and ST-302 Ball Joint Vise.

Continue with disassembly of compressor components as described below. Fig. 12-2-7.

1. Remove accessory drive pulley key, if used. Fig. 12-2-8.
2. Place accessory drive pulley capscrew in end of shaft t prevent damaging threads.
3. Install puller and remove drive gear and roller bearing (used) from compressor crankshaft. Fig. 12-2-9.
4. Remove drive gear key from crankshaft.
5. Install Item #3 of ST-749 Mounting Plate to hold cranksha securely while removing counter weight capscrew.
6. Unlock counterweight lockplate; remove capscrew, lock plate and washer.
7. Replace capscrew to prevent damage to crankshaft thread
8. Install puller and remove counterweight. Fig. 12-2-10.

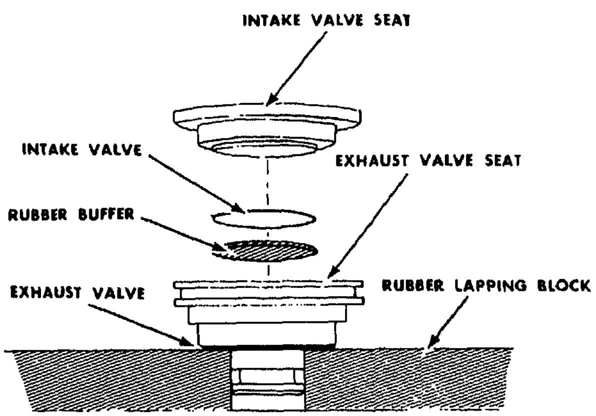


Fig. 12-2-6. Lapping valve N11217

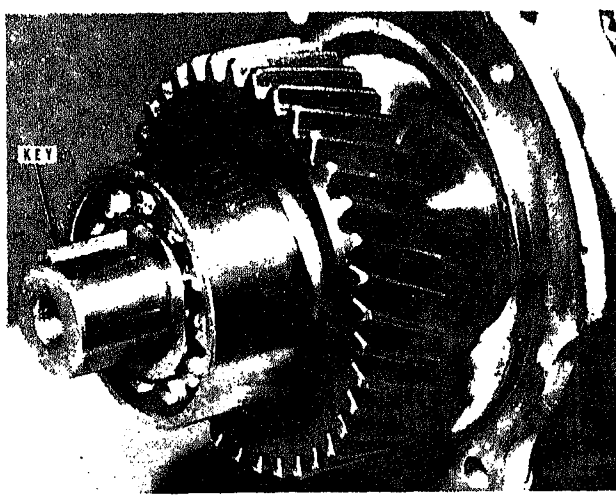


Fig. 12-2-8. Remove accessory drive pulley key N112

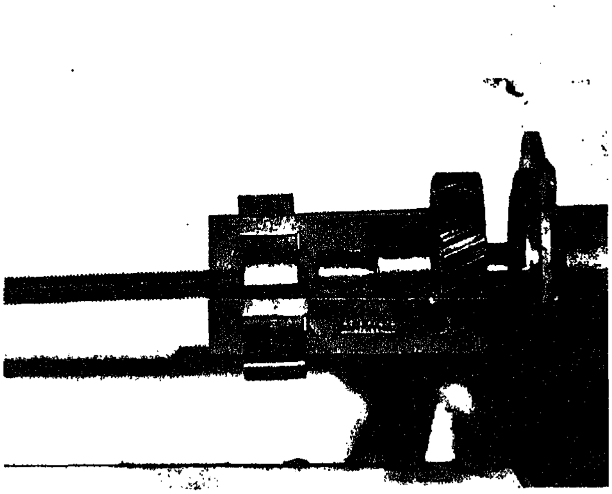


Fig. 12-2-9. Remove drive gear and roller bearing N11220

Caution: Do not assemble puller capscrews in far enough to contact and/or damage connecting rod.

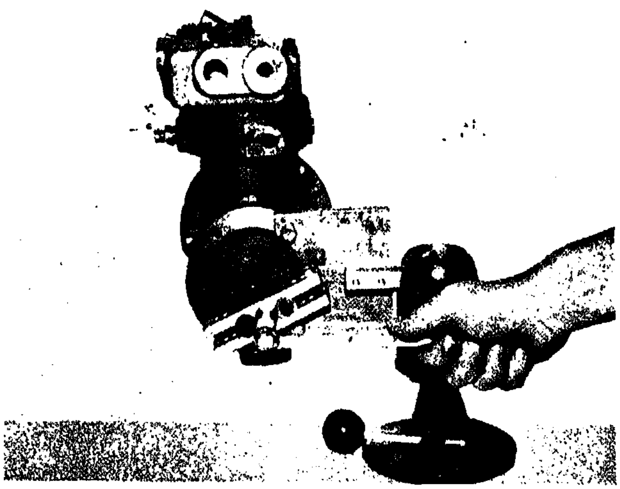


Fig. 12-2-10. Remove counterweight N11221

Loosen capscrews holding support to crankshaft; remove support and crankcase assembly by tapping support with a plastic mallet. Fig. 12-2-11.

Caution: Proceed carefully to prevent damage to connecting rod bushing.

After removing support from crankcase, use an arbor press to press crankshaft from thrust bearing retaining sleeve and/or gear, roller bearing and support housing. Fig. 12-2-12.

Remove thrust bearings from support housing and crankshaft. Figs. 12-2-13 and 12-2-14.

Clean carbon from worn ridge at top of crankcase bore then push piston and rod assembly out top of crankcase.

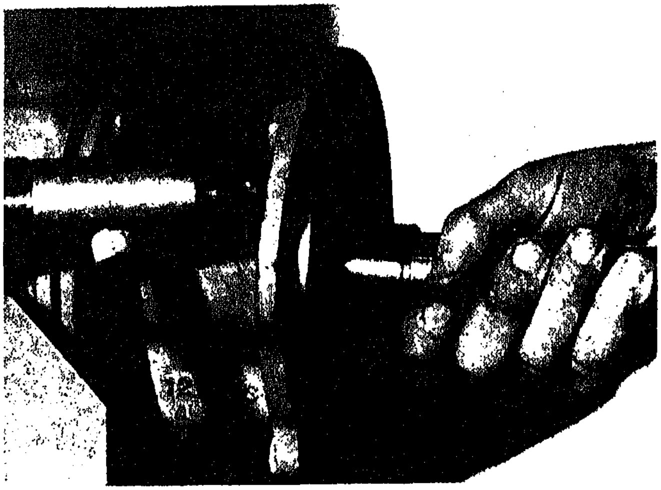


Fig. 12-2-11. Remove support from crankcase N11222

13. Remove piston rings.
14. Using needle nose pliers, remove the piston pin snap ring.
15. Place piston in hot water for a few minutes to expand pin bore.
16. Push pin from piston with thumb and remove rod.

    Caution: Do not drive pin from piston.

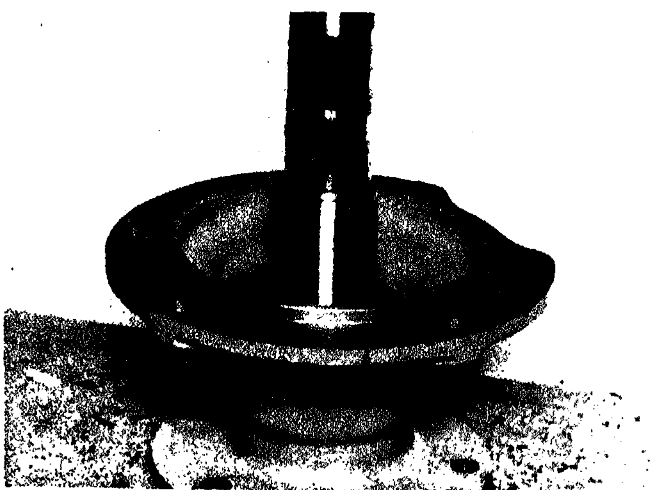


Fig. 12-2-12. Press crankshaft from retaining sleeve N11223

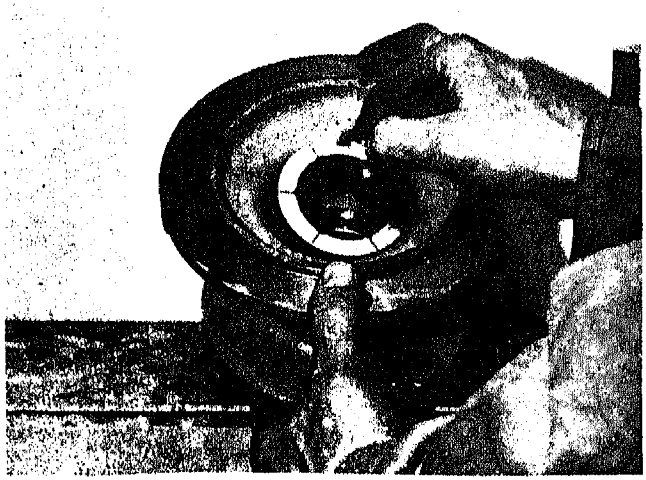


Fig. 12-2-13. Remove retaining sleeve and thrust bearing N11224

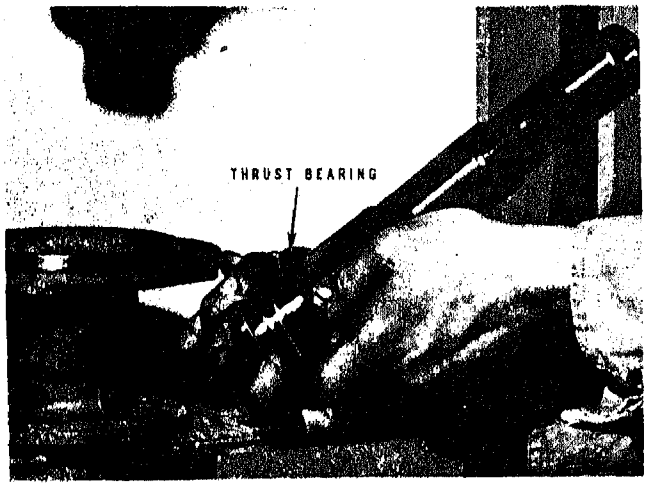
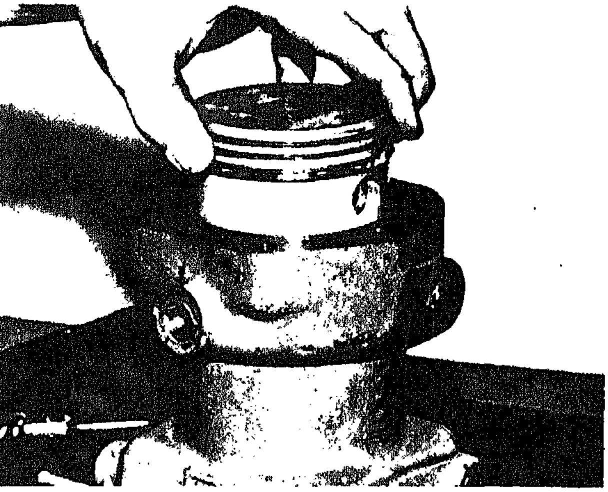


Fig. 12-2-14. Slide thrust bearing from crankshaft N11225



. 12-2-17. Remove piston and rod assembly N11228

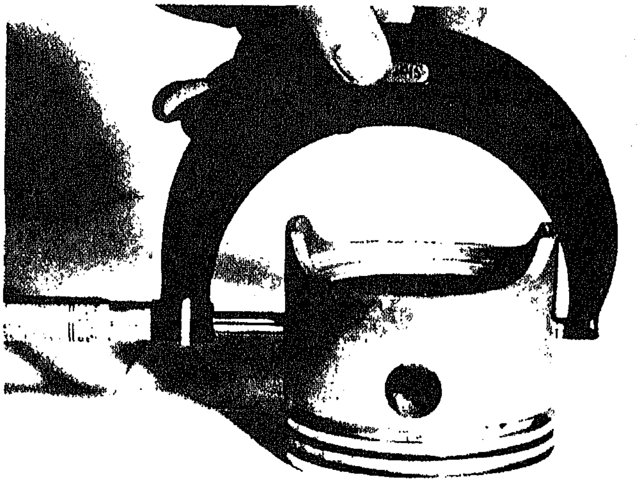


Fig. 12-2-19. Check piston for wear N11230

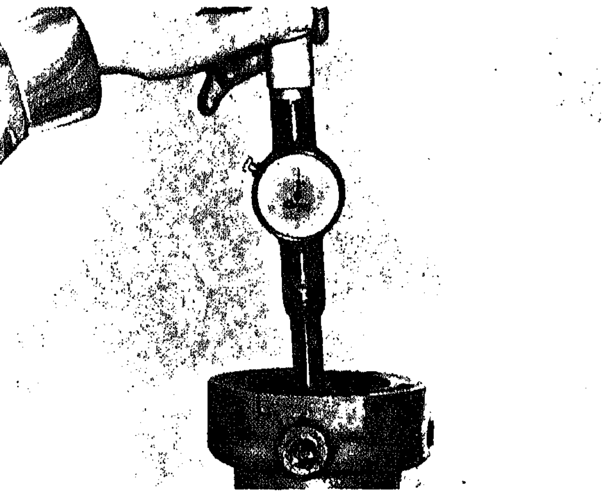
Inspection Crankcase and Crankshaft

1. Check cylinder bore for out-of-roundness and wear with a dial bore gauge. Fig. 12-2-18. Hone bore with 150 grit stone, wet, to accommodate .010, .020 or .030 inch oversize pistons if:

a. Out-of-roundness exceeds .0015 inch.

b. Bore is worn beyond 3.443 inch.

2. Visually inspect bore for scoring. Hone oversize as necessary.



. 12-2-18. Check cylinder bore N11229

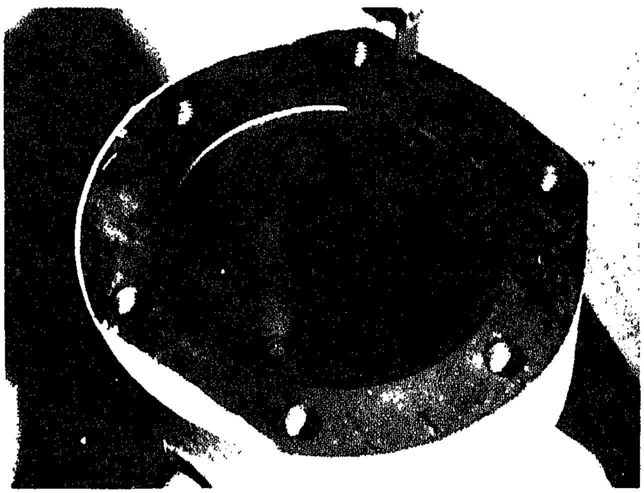


Fig. 12-2-20. Check ring gap N11231

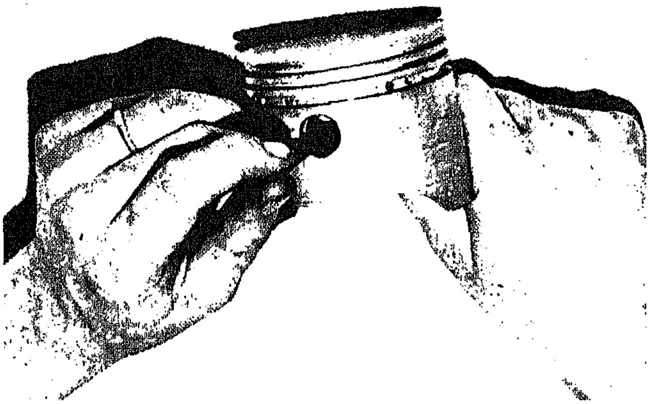


Fig. 12-2-21. Check piston pin bore N11232

3. Check crankshaft nose for damage to threads.

4. Check crankshaft machined surfaces for scratching and scoring and support journal for wear. See wear replacement limits given on Page 12-2-13 Table 12-2-3. If support journal wear exceeds worn replacement limit, the crankshaft support journals must be reground to accept undersize support bushings. Support bushings are available in .010, .020, .030 and .040 inch undersize. Connecting rod bearings are available in .010, .020, .030 and .040 inch undersize.

Inspection Piston, Connecting Rod and Supports

1. Inspect piston for scoring, cracks or other damage.

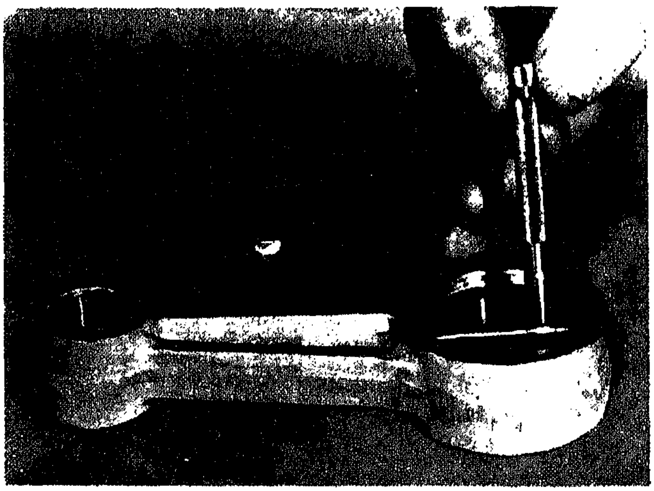


Fig. 12-2-22. Check connecting rod bushing N11233

Fig. 12-2-23. Check support bushing

2. Measure piston wear one inch below and at right a to the piston pin bore. Fig. 12-2-19. If skirt diameter is than 3.433 discard piston.

3. Compare cylinder bore ID and piston OD to check cyl bore-to-piston clearance. Clearance must not exceed inch.

4. Check ring groove wear.

a. Install a new ring in top groove of piston.

b. Insert a .004 inch feeler gauge between ring and p groove.

c. Compress ring in piston groove. If ring is below piston surface with feeler gauge in place, wear is excessive piston must be discarded.

5. Place new ring in cylinder bore and check ring enc

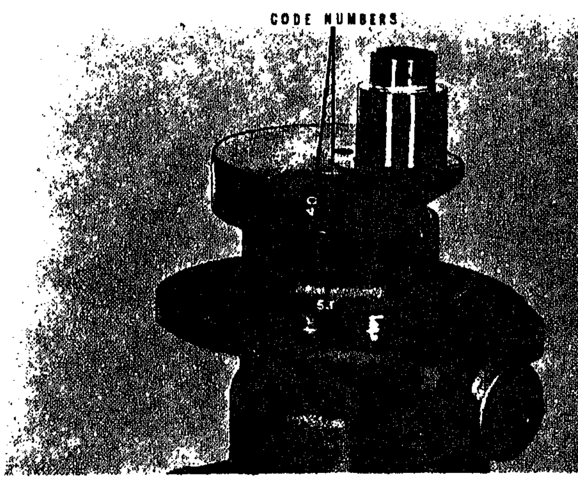


Fig. 12-2-24. Crankshaft and support number

Fig. 12-2-25. Install thrust bearing N11236

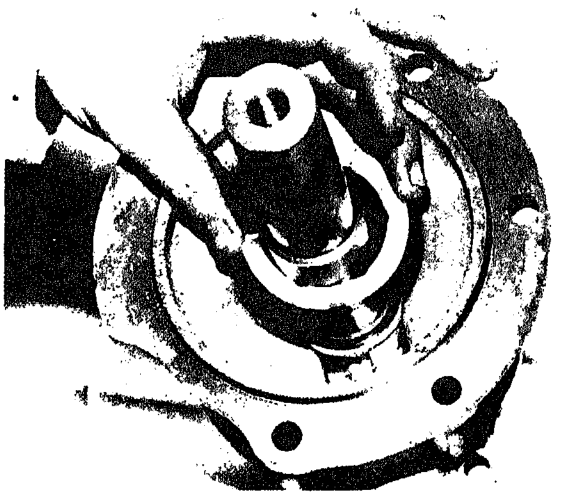


Fig. 12-2-27. Install thrust bearing N11238

with a feeler gauge. Fig. 12-2-20. Check Table 12-2-3 for limits.

Check piston pin bore with a telescope gauge. If worn beyond wear limits in Table 12-2-3, discard piston. Fig. 12-2-21.

Check connecting rod bearing I.D. with a telescope gauge. If I.D. exceeds 1.3787 inch on one-piece connecting rod, discard connecting rod. If two-piece connecting rod is used, discard bearing shells and replace new shells during assembly. Fig. 12-2-22.

Check support bushing I.D. with telescope gauge. If I.D. exceeds 1.757 inch, press out support bushing. Fig. 12-2-23.

Note: Use ST-695-2 Mandrel to remove support bushings on gear driven compressor.

Assembly — Gear Driven Compressor

1. Lubricate support bushings and install with oil holes aligned. Use ST-695-1 Mandrel for all gear-driven compressors. Bushings must be installed .120/.130 inch below surface.

2. Select thrust bearings from Table 12-2-1 to provide proper crankshaft end clearance. Apply Lubriplate Type 130AA to grooved side of thrust bearing. Install thrust bearing with grooved side out. Fig. 12-2-25. New thrust washers will be wavy.

3. Install crankshaft in crankcase end of support housing. Fig. 12-2-26.

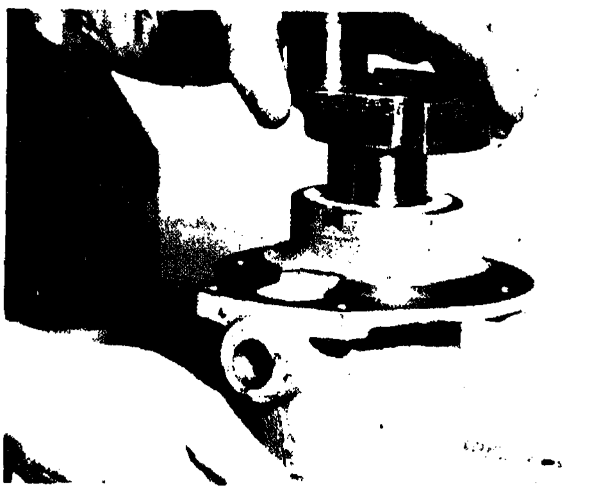


Fig. 12-2-26. Install crankshaft N11237

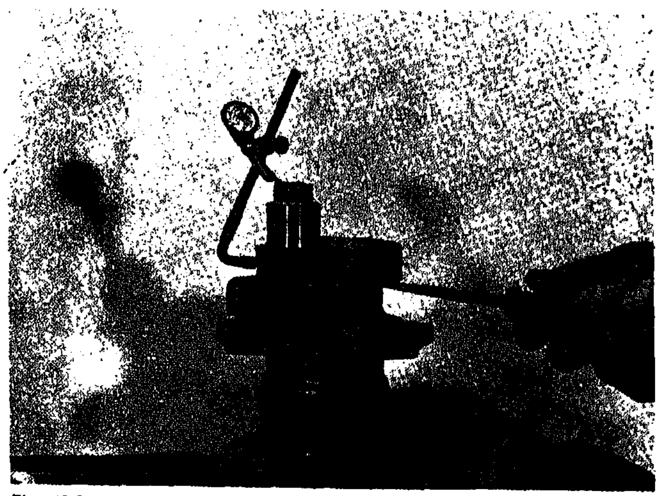


Fig. 12-2-28. Check crankshaft end clearance N11239

4. Turn support housing over. Apply Lubriplate to grooved side of second thrust bearing and install with grooved side up.

a. On J, C, H-NH (EOL) engines, apply Lubriplate to thrust bearing retaining sleeve and press sleeve over crankshaft flush with thrust bearing. Install key in crankshaft. Apply Lubriplate to drive gear and press gear onto crankshaft flush with shoulder.

Note: install spacer on crankshaft. Press roller bearing onto crankshaft flush with drive gear.

6. Check crankshaft end clearance. Fig. 12-2-28. Clearance must be .004/.009 inch. (It is necessary to manually deflect [depress] waviness from thrust washer to make end clearance tolerance check).

7. Heat piston in water to expand piston pin bore and install piston pin through piston and connecting rod. Fig. 12-2-30. Secure pin with snap rings.

Caution: Do not drive pin through piston.

8. Install ring expander and piston rings on piston. Fig. 12-2-29. To improve ring break-in, install red oxide coated compression ring in second groove.

Caution: Keep word "top" on compression rings to top. If piston and rod assembly are held by a vise use small blocks of soft wood to prevent vise marring rod.

9. Lubricate with oil and install piston and rod assembly in crankcase using a sleeve type ring compressor; install with one swift smooth motion, do not just tap in, oil ring rail may pop out.

10. Mount crankcase assembly on ST-749 Mounting Plate.

11. Apply Lubriplate Type 130AA to connecting rod bushing

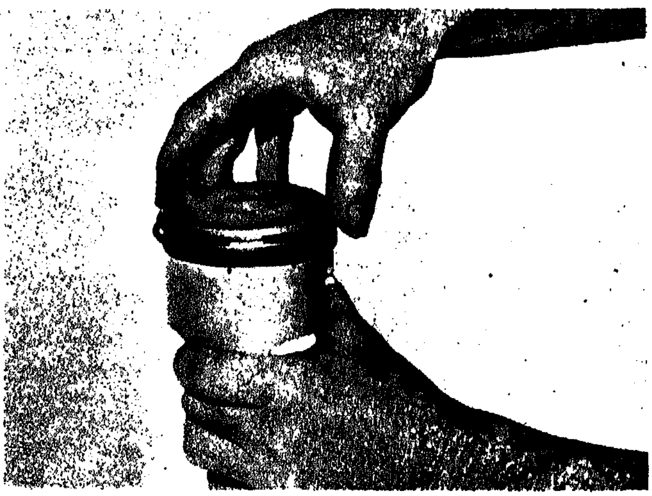


Fig. 12-2-29. Install piston rings N11240

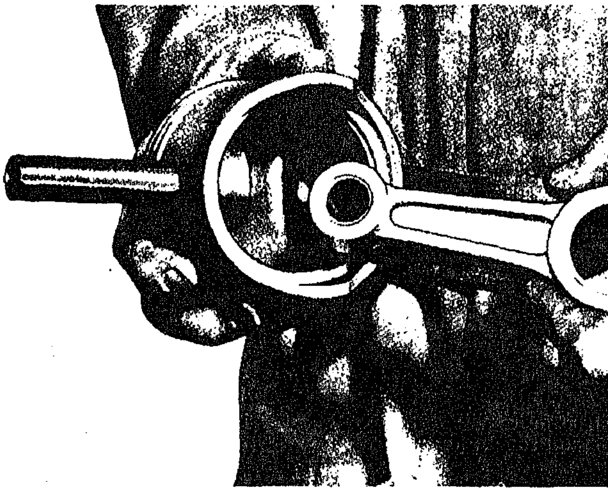


Fig. 12-2-30. Install piston pin N1

and support bushing. Assemble support gasket to cra case; slip crankshaft through connecting rod and sec support to crankcase with lockwashers and capscrews.

Caution: Do not damage crankshaft during assembly p cedure.

12. Install the counterweight key in the crankshaft.

13. Using a plastic mallet, start the counterweight on the sl Counterweight must then be pressed on until flush crankshaft shoulder.

14. Install the counterweight washer, lockplate and capscr

15. Install Item #3 of ST-749 to mounting plate.

16. Tighten counterweight capscrew to 40 ft. lbs. Fig. 12-2-

17. With an indicator, check connecting rod side clearanc shown in Fig. 12-2-32. Clearance must be .003/.008 inc (Lock lockplate.)

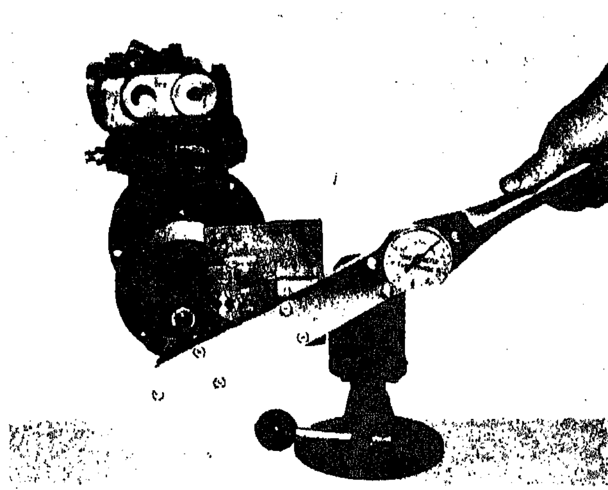


Fig. 12-2-31. Tighten counterweight capscrew N

Install new cylinder head gasket.

Place cylinder head on crankcase and secure with lockwashers and capscrews. Tighten capscrews to 35 foot-pounds.

Using Thrust Bearing Chart

Table 12-2-1 below will enable you to make selection of thrust washer combinations necessary to provide correct crankshaft end clearance.

Follow horizontal column under crankshaft number until it intersects the vertical column under support number. Intersection of these columns provide appropriate bearing combinations. For example, a #53 support and a #40 crankshaft require a combination of one "A" and one "B" bearing for proper end clearance. A #52 support and a #37 crankshaft requires a combination of two "A" bearings for proper end clearance.

Thrust bearing part numbers are given in Table 12-2-2 following.

Note: When ordering use part number only. DO NOT USE CODE LETTER.

Table 12-2-2: Thrust Bearings Size and Code

Thrust Bearing	Size	Chart Code Letter
#130080	.088-.090	A
#130081	.090-.092	B
#130083	.092-.094	C
#130082	.100-.102	NONE

Table 12-2-1: Thrust Bearing Chart

Support Number	Crankshaft Number										
	40	39	38	37	36	35	34	13	12	11	10
53	AB	AB	AA	AA							
52	BB	AB	AB	AA							
51	AC	BB	AB	AB							
50	BC	AC	BB	AA	AA	AA	AA				
49	BC	BC	AC	AB	AB	AA	AA				
48	CC	BC	BC	AB	AB	AA	AA				
47				BB	BB	AB	AA				
46				BB	BB	AB	AB				
45				BC	BC	BB	BB				
26								AB	AB	AA	AA
25								BB	AB	AB	AA
24								AC	BB	AB	AB
23								BC	AC	BB	AB
22								BC	BC	AC	BB
21								CC	BC	BC	AC

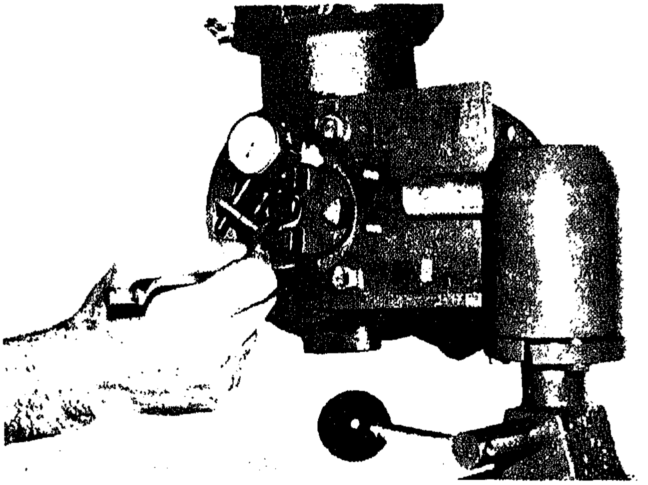


Fig. 12-2-32. Check connecting rod side clearance N11243

Governors and Pressure Settings

Governor settings may be adjusted to a maximum operating pressure of 125 psi for compressors supplied with Cummins engines.

Air Compressor Piping

The recommended piping diagram for Cummins Air Compressor where used with or without the alcohol evaporator, is shown in Fig. 12-2-38. Where not required, omit evaporator and connecting two lines.

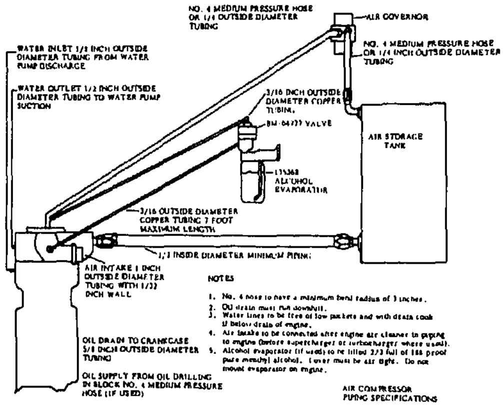


Fig. 12-2-38. Air compressor piping specifications N1120

Table 12-2-3: Worn Replacement Limits — Cummins Compressor

Unit No.	Part Name or Location	New Dimensions Minimum	New Dimensions Maximum	Worn Replacement Limit
1201	CRANKCASE:			
	Crankcase bore	3.4395	3.4405	3.4430
	PISTON:			
	Piston skirt dia. (at 70°F.)	3.4355	3.4365	3.4330
	Piston pin bore (at 70°F.)	.6875	.6880	.6890
	Ring grooves #1 comp.	.095	.096	.098
	#2 comp.	.095	.096	.098
	oil ring	.188	.189	.191
	Ring gap clearance (In new crankcase bore at 3.4395 in.)			
	#1 comp.	.010	.020	
	#2 comp.	.010	.020	
	oil ring	.010	.015	
	Piston pin	.6874	.6876	.6869
	CONNECTING ROD:			
	Rod bend		.002	
	Rod twist		.005	
	Piston pin bushing	.6880	.6885	.6895
	Crankshaft bushing (one-piece)	1.3762	1.3772	1.3787
	CRANKSHAFT:			
	Connecting rod journal	1.3740	1.3750	1.3725
	Rear support journal	1.7495	1.7505	1.7485
	Front journal (I.O.L. engines only)	1.5615	1.5620	1.5605
	Rear support bearings (140420)	1.7530	1.7550	1.7570
	Front crankshaft bearing (I.O.L. engines only)	1.5665	1.5685	1.5705
	End Clearance	.0040	.0090	.0120

uble Shooting — Air Compressors

Complaints

Compressor fails to maintain adequate pressure in the air orake system.

Note: Check compressor unloader valve action as indicated under "D".

Possible Cause

1. Air governor set improperly, or malfunctioning.
2. Excessive carbon in compressor cylinder head or discharge line.
3. Discharge valve leaking.
4. Excessive wear.
5. Intake valve stuck open.
6. Excessive leakage of intake valve.
7. Unloader cap stuck.
8. Leaks in vehicle air system.
9. Check valve inoperative.

Voisy Operation

1. Same as Step #2 above.
2. Worn or burned out bearings.
3. Same as Step #4 above.
4. Worn gears.
5. Excessive end play.

Compressor Passes Excessive Oil

s unit really pumping oil?

How to check:

Bleed air tanks slowly — if black and oily — no good; if gray, oil pumping not too bad, but may still need repair; if all water with slight oil film — O. K

Check for oil pumping

Varm engine up to operating temperature.

Disconnect air discharge line at compressor head.

Jse shop air at 100 psi at unloader valve to unload compressor.

Operate compressor in unloaded condition for 10 minutes.

Place white cloth over air discharge port.

Disconnect shop air from unloader valve and operate compressor for 10 minutes.

f compressor is not pumping oil, only a faint trace of gray vill show on white cloth.

Another more time consuming method is to steam clean vet tank and have customer operate unit for one or two rips.

Note: Just because there is oil in the air tanks is not proof hat the compressor is presently pumping oil. There have been many cases where corrections have been effected, out the oil in the tanks takes a long time to dissipate.

Remove unloader valve assembly and check exhaust valve and air discharge passage for oil.

Complaints	Possible Cause
Remove cylinder head, check cylinder bore for:	
Vertical scratches.	
Taper.	
Out-of-round.	
Rings seating.	
Signs of distress — valve spring breakage — etc.	
99% of the oil pumping air compressors inspected have been found to have one or more deep vertical scratches in the bore. Why scratches? Carbon ring installation, dirt and failed valves or springs.	
Reasons for oil consumption.	1. Same as Step #4 under item A. 2. Excessive oil pressure. 3. Back pressure from engine crankcase. 4. Piston rings improperly installed or broken. 5. Carbon from head dropping into bore and scratching cylinder walls. 6. Bent rod.
Correct oil pumping.	
. Block	
. Make certain that orifice is not used to limit lube oil supply; front support or crankshaft.	
2. Check cylinder bore to determine if it needs honing oversize and resolve what specific oversize dimension should be used for honing operation. (Pistons are available in .010, .020 and .030 oversize).	
3. Hone cylinder bore with 150 grit stone, wet, and obtain 45° cross-hatch pattern.	
4. After honing, note that there is a slight burr, left by the hone, at the top of the bore, just at the lower edge of the top bore chamfer. Be sure to remove the burr.	
5. Wash block to remove all traces of hone material.	
b. Piston and Rings	
1. Inspect piston for wear-skirt-ring grooves etc. Also note wear pattern on skirt, if uneven below pin bosses, there may be too much clearance in front support to crank or the rod may be bent or twisted. Make sure piston is latest style as outlined in Service Letter 6355.	
2. Install new rings on piston. Rings as per reference Service Letter 6355.	
3. Check rod for proper pin and crank bore sizes; check for bend and twist.	
D. Compressor Does Not Unload See checking procedure following:	1. Air governor working improperly. 2. Defective unloader or cap guide seal. 3. Unloading cavity plugged with carbon.

omplaints

Possible Cause

4. Unloading cap binding or stuck.

5. Unloader spring failure.

6. Unloader cap not seating properly on intake valve seat.

Checking Cummins Air Compressor Unloader Valve Spring Action

The following checking and adjusting procedures are for your use in trouble-shooting air compressors not pumping or slow pressure build-up air tank pressure. Our investigations show that these complaints are usually caused by one or more of the following:

mproper tension on the unloader valve spring.

Air governor not dumping air pressure from the compressor unloader valve.

Carbon deposits, worn or broken compressor intake and exhaust valves, seats and springs.

Worn or broken (chipped) intake and exhaust valves, valve seats and springs can be determined by simple visual examination.

The air governor is designed to function to control the air compressor so that air tank pressure is maintained in the range of 90 to 120 psi. Proper functioning of the air governor can be checked by installing a pressure gauge in the line between the air compressor and air governor and checking whether the governor functions correctly. In some cases the passages in the governor or connecting lines have become clogged so the pressure necessary to actuate the compressor unloader valve is not transmitted to the compressor. When clogging occurs, cleaning or repair of the air governor is necessary to restore proper operation.

Proper functioning of the compressor unloader valve depends upon the spring tension on the unloader cap which must be adjusted so the cap will actuate and unload the air compressor at a lower pressure than will be applied through the air governor. Also, the cap must retract and allow the compressor to start pumping when the pressure on the unloader cap is more than atmospheric pressure. The unloader valve should be adjusted so it will function as follows:

he unloader valve should actuate to unload or stop air ompressor pumping when pressure on the cap from the ir governor, or as applied by other means, reaches a minnum of 60 psi.

he unloader valve should open or retract and allow the ir compressor to pump when pressure on the cap is reuced to a minimum of 10 psi.

Operation of the unloader valve may be checked by applying shop air pressure to the unloader valve cover

Complaints

Possible Cause

Some arrangement must be used so the pressure may be varied from zero (0) to approximately 100 psi. A simple arrangement of two valves, a pressure gauge and connections can be used for this check. One of the valves must be arranged to bleed off air, then by adjusting both valves, the pressure applied to the unloader cap can be varied as desired.

With the above arrangement, operation of the unloader valve may be checked as follows:

1. Disconnect the air compressor discharge line at the compressor and with engine running at rated speed gradually increase air pressure on the compressor unloader valve until air compressor unloads or stops pumping. Note pressure on gauge at which this occurs.

2. Gradually decrease pressure on unloader valve until air compressor begins to pump. Note pressure at which this occurs.

Note: Pressures on the unloader valve at which the air compressor loads and unloads vary with engine speed and is approximately 20 psi higher at idle. **Therefore, it is important that these checks be made at engine rated speed.**

3. If the pressure in Step 2 is less than 10 psi, check the unloader cap to make sure it is free in the body. On some occasions sharp edges or burrs on the body have caused unloader caps to stick. Correct by polishing edges of the body or otherwise making certain the unloader cap works freely in the body.

4. If unloader cap is working freely, add a sufficient number of shims, Part No. 67990, between cap and spring to adjust spring tension so unloader valve will retract and load air compressor at a minimum of 10 psi pressure on the valve at rated engine speed.

5. Never add more shims than necessary to get air compressor to load with 10 to 15 psi pressure on the unloader valve at rated engine speed. Excessive shimming may prevent unloader valve from closing to unload the air compressor.

6. After adjustment, connect air compressor discharge line and governor line. Recheck air compressor loading and unloading by reducing air pressure in tanks with brakes or other means two or three times. Also, allow engine to run at rated speed for a few minutes after air compressor is unloaded by maximum air tank pressure, as it should under normal operation. This check is to insure that the compressor is unloading completely. During check, the vehicle air gauge hand should not creep if adjustments are made correctly.

E. Compressor head leaking water.

1. Capscrews not tight.
2. Excess torque on valve assembly capscrews.
3. Head or head cover porous or cracked.
4. Fittings not properly installed.

Electrical Equipment Group

The principle function of the Electrical System
is that of cranking or starting and c
erating electrical accessories as required by the unit bei
powered.

Cranking Motor—Unit 1301

Electrical Cranking System

This unit includes:

Electric Cables and Connections
Ground Connections
Cranking Motor
Series-Parallel Switch
Batteries

The information contained in this section is limited to a brief description of the function and operation of electric units and to simple tests and adjustments that can be made without special equipment.

Electric Cables and Connections

Electric current traveling through a wire may be compar to water flowing through a hose or pipe. Voltage in t electric circuit is like pressure behind water in the ho Water pressure is lost if it is allowed to leak or if hc diameter is so small that it offers resistance to flow. T loss of water pressure compares with loss of electric pr sure, or voltage, because of poor connection or conduct of insufficient capacity.

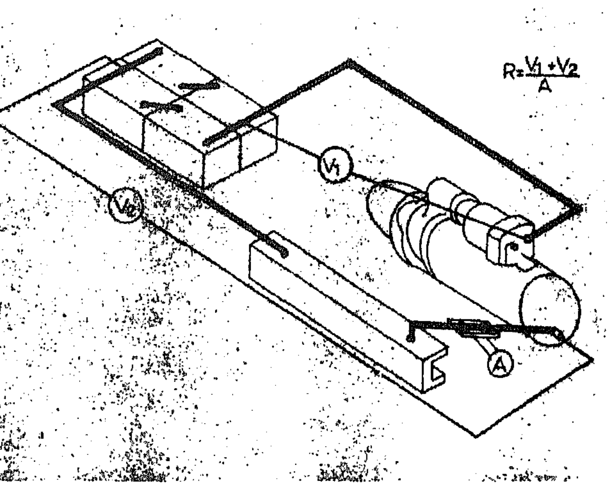
Battery Cables

Starter circuit resistance can have a significant effect performance of the system to satisfactorily start engi An increase in the circuit resistance, due to cable and cc nection deterioration, will reduce cranking speed and sta er cranking torque and result in more difficult engine sta ing, even with batteries of poor capacity.

The total resistance of the circuit must not exceed "ma mum circuit resistance" shown in Table 13-1-1. Resistar reduces electric current and cranking effort. The low-vc age high-amperage current in the cranking motor circ requires heavy-duty cables and good connections. Batt cable size is based on total cable length (over to star and back to battery).

Ground Connections

In engine applications a common ground connection sometimes used. This system uses the metal of the unit one side of the electric circuit and, as such, makes metal that lies between electric unit and battery or g



g 13-1-1. Single battery location — small pair of bles with frame ground return N11313

ame solid metal member.

n occasion may arise when the battery is grounded to one eam of the frame and it is necessary to make ground conections to a second beam or section of the superstructure hich is jointed to the first. This can be done safely if you rst bolt and sweat-solder a flexible, heavy metal strap etween the two beams to bridge the joint. This has the ffect of making the jointed member a part of the beam hich grounds the battery. All metal joints in the circuit hould be treated in this manner. This will also hold true or instrument ground connections in the cab, on the intrument panel, etc.

lany engines and cabs are installed on rubber or other exible mountings. These mountings, in themselves, proide practically no electric connection to the frame. Even solid-type engine mounting in which the flywheel housing is bolted directly to the frame makes a poor electric connection. All ground connections from any electric unit should be made to the same solid or bridged metal member to which the battery itself is grounded.

Never install a battery or electric connection in a dirt stream or where excessive dirt, oil or corrosion will collect. Dirt, oil and corrosion act as an effective resistor, taking away current needed for engine cranking. Never attach ground wires to a rusty, greasy, or dirty surface.

Regardless of where magnetic switches, cut-out relays, and other control units are mounted, a separate ground wire should be run from the proper terminal or designated part

of the unit to the same solid metal member grounding the battery. Whenever possible, make ground connections directly to the battery's grounding bolt. This will provide a dependable ground return circuit and permit unretarded passage of current to allow units to function as they are intended.

The sketches shown here indicate the proper method of grounding certain units. They are not complete wiring diagrams, and under no circumstances should they be used as such.

To make a good electric connection between a cable terminal and the frame, you must clean and scrape metal surfaces until they are bright; then tin these surfaces to prevent rust and corrosion. To make a dependable, permanent joint, sweat-solder cable and frame after they are bolted together.

The heavy cables used to make ground connections from the battery, cranking motor or engine should not swing. A single bolt connection as shown in Fig. 13-1-6 is unreliable. The surface of frame at the joint is not tinned and, in addition, the heavy cable can swing back and forth to lo connection. Loose connections leave a space bet cable terminal and frame, which may allow the entran dirt or moisture to form rust or corrosion.

Recommended ground connections and methods of venting cable swing are shown in Fig. 13-1-7. The su of the frame at the connection is tinned to prevent rus corrosion.

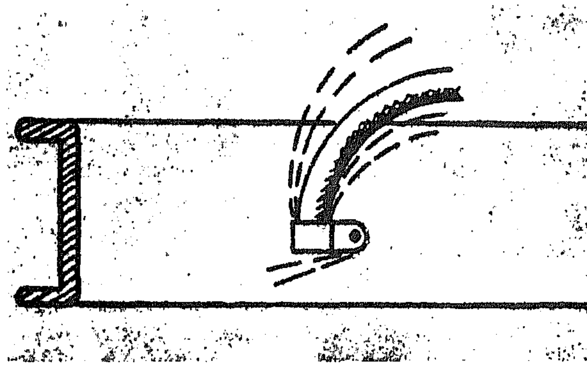


Fig. 13-1-6. Unreliable ground cable

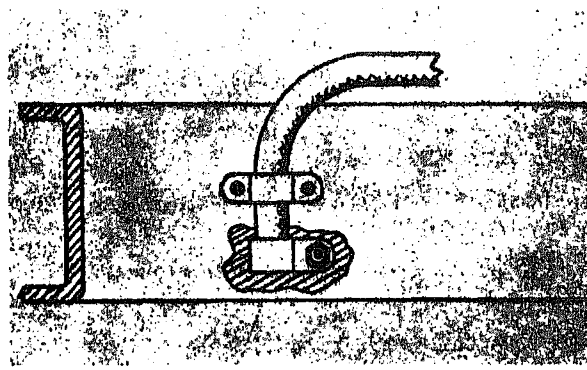


Fig. 13-1-7. Reliable ground cable

Table 13-1-1: Cable Sizes — Total Length Allowable in Cranking Motor Circuit Using Cable Sizes Indicated

		B and S Gauge and Length							
	Maximum					#0000 Or			
	Circuit	#00		#000		Two #0		Two #00	
Circuit Voltage	**Resistance**	**Ft.**	**[m]**	**Ft.**	**[m]**	**Ft.**	**[m]**	**Ft.**	**[m]**
12-V	0.001 Ohm	To 10	[3.048]	10/12	[3.048/3.6576]	12/15	[3.6576/4.572]	15/19	[4.572/5.79
12-V High Output Starting Motor	0.00075 Ohm	To 6	[1.8288]	6/8	[1.8288/2.4384]	8/10	[2.4384/3.048]	10/13	[3.048/3.96
24-V to 32-V	0.002 Ohm	To 20	[6.096]	20/27	[6.096/8.2296]	27/35	[8.2296/10.668]	35/45	[10.668/13.

Note: Two strands of #0 cable may be used in place of one #0000 cable provided all connections are carefully made. is to insure that current in each parallel cable will be equal. The cross sectional circular mil area of #0000 cable is double

Cranking Motors

The cranking motor is a special overload motor capable of delivering high horsepower. In order to obtain this power, it is necessary to build the cranking motor with a minimum of resistance so a large current will be taken through it. The cranking motor should be used for short periods only (30 seconds maximum) to avoid the possibility of failure due to overheating.

The cranking motors , are of the 24 volt series. The voltage rating must be selected to be compatible with engine cranking requirements as well as system voltage.

Cleaning

All parts should be cleaned after disassembly. Do not clean the armature or fields in degreasing tank; compounds used in this type of cleaner may cause damage to mica or enamel insulation and rubber.

If the commutator is dirty, it may be cleaned with a strip of No. 00 sandpaper.

Caution: Never use emery cloth to clean commutator.

All dust must be blown from cranking motor after commutator has been cleaned.

If commutator is rough, out-of-round, or has high mica, remove unit from engine and disassemble armature. Turn the commutator down in a lathe, removing only sufficient material to true-up the commutator and remove roughness and high mica. Undercut the mica.

Replace worn brushes. If brushes wear rapidly, check for incorrect brush spring tension and roughness or high mica on the commutator.

Lubrication

All bearings provided with hinge cap or ball-type oilers should have 8/10 drops of light engine oil every 400 hours. lubrication.

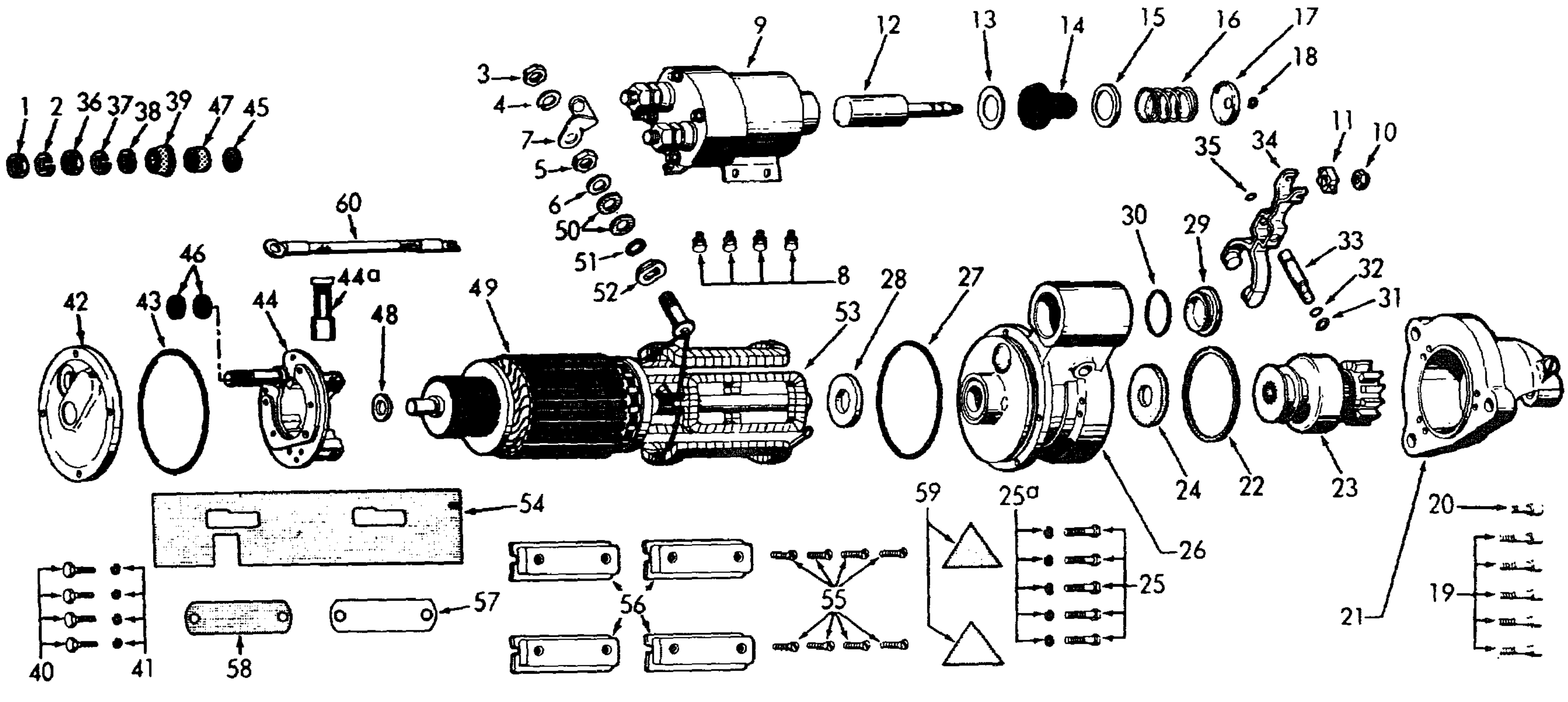
On units so equipped, keep grease cups filled with medium cup grease. Turn down one turn every 400 hours for proper lubrication.

3. Oil plugs should be removed every 6 months and the reservoir packed with graphite grease. On tractor, marine and stationary applications, lubricate at every unit rebuild.
4. Do not lubricate excessively, since excessive oiling may cause oil and grease to gum on the commutator and reduce the cranking ability of motor. Never oil commutator.
5. On some models, oil wicks are used for lubrication of the center or drive-end bearing. The wick is saturated with oil before assembly. When the cranking motor is removed from engine, oil wick should be saturated with oil before unit is reinstalled.
6. All oilless-type bushings should be supplied with a few drops of light engine oil whenever disassembled.
7. Lubricate cranking motor drives with a few drops of light engine oil during installation. Avoid excessive oiling.

Cranking Motor Controls

1. Because of high current flow from battery to cranking motor during cranking, a positive means of connecting and disconnecting battery and cranking motor must be used. The switch used must have contacts of adequate size to carry current without burning. A manually operated switch mounted on the floor board or cranking motor frame is the simplest type.
2. Some applications use a magnetic switch —a small electromagnet—which, when energized, draws in a plunger and causes a contact disc to make contact between two terminals to complete the circuit from battery to cranking motor. The magnetic switch winding is usually energized by a push button.
3. Some applications with the overrunning clutch use a somewhat larger magnetic switch called a solenoid switch. Here, the plunger not only thrusts against a contact disc to close the battery-to-cranking motor circuit, but is also linked to the shift lever so the drive pinion is shifted into mesh with the flywheel teeth by the solenoid action. The solenoid switch is usually actuated by a push button.
4. The series-parallel system is designed to provide a means of connecting two batteries in series to provide increased voltage for cranking, and reconnecting the two batteries in parallel for normal operation of electrical equipment after starting has been accomplished.

Cranking Motor Drives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Nut
Lockwasher
Nut
Lockwasher
Nut
Washer, plain
Connector
Screw and lockwasher
Solenoid switch
Nut, plunger rod adjusting
Guide, plunger
Plunger assembly
Washer, retainer
Boot
Washer, retainer
Spring
Retainer, spring
Nut
Screw
Screw
Drive housing
"O" ring
Motor drive clutch
Washer, brake
Screw
Lockwasher
Lever housing
Gasket
Washer, space
Retainer, spring
"O" ring
Snapring

32 "O" ring
33 Shaft, lever
34 Lever, shaft
35 Snapring
36 Nut
37 Lockwasher
38 Washer, plain
39 Insulator
40 Screw, frame attaching
41 Lockwasher
42 Commutator end frame
43 "O" ring
44 Brush plate assembly
44a Brush
45 Washer, plain
46 Washer, insulating
47 Bushing, terminal stud insulating
48 Thrust washer
49 Armature
50 Washer, insulating
51 Gasket
52 Bushing, terminal stud insulating
53 Field coil
54 Insulator, field coil
55 Screw, pole shoe
56 Pole shoe
57 Insulation, pole shoe
58 Insulation, pole shoe
59 Insulation

Figure 13-1-8. Cranking motor.

Overrunning Clutch Drive — Roller Type

1. The overrunning clutch is designed to provide positive meshing and disengagement of drive pinion and flywheel ring gear. It uses a shift lever that slides the clutch and drive pinion assembly along armature shaft so it can be meshed and disengaged as required. The clutch transmits cranking torque from cranking motor to engine flywheel but permits drive pinion to overrun, or run faster than, the armature after engine is started. This protects armature from excessive speed during brief interval that the drive pinion remains in mesh.

2. The overrunning clutch consists of a shell and sleeve assembly that is splined internally to match splines on armature shaft. Thus, both the shell and sleeve assembly and armature shaft must turn together. A pinion and collar assembly fits loosely into shell, and the collar is in contact with four matched steel rollers that are assembled into notches cut in the inner face of shell. These notches taper inward slightly so there is less room in the end away from rollers than in the end with rollers. The rollers are spring-loaded by small plungers.

3. When shift lever is operated, clutch assembly is moved endways along armature shaft so pinion meshes with flywheel ring gear. If teeth should butt instead of mesh, clutch spring compresses so pinion is spring-loaded against ring gear teeth. When armature begins to rotate, meshing takes place at once. Completion of shift lever movement closes cranking motor switch so armature begins to rotate. This rotates shell and sleeve assembly, causing rollers to jam tightly in smaller sections of shell notches. The rollers jam between pinion collar and shell so pinion is forced to rotate with armature and crank engine.

4. When engine begins to operate, it attempts to drive cr ing motor armature, through the pinion, faster than ar ture is rotating. This causes pinion to rotate with res to the shell so it overruns shell and armature. The ro are turned back toward larger section of shell notc where they are free, and thus permit the pinion to over This protects armature until automatic controls take so the shift lever is released, causing shift lever sprin pull overrunning clutch drive pinion out of mesh from gine flywheel ring gear. This shift lever movement opens cranking motor switch so armature stops rotating

Checking An Improperly Operating Cranking Motor

1. If cranking motor does not develop rated torque and cr engine slowly or not at all, some indication of the so of trouble may be gathered by turning on the lights attempting to crank.

a. If lights go out as cranking motor switch is closed, probable that a poor connection exists at battery termi or elsewhere in the circuit.

b. If lights dim considerably, but still burn, it is likely that battery is run down. Or, possibly there is some mechar trouble either in the cranking motor or in the engine makes it difficult for cranking to take place, and an ex sively high current drain on the battery consequently sults.

f lights do not dim, it indicates there is no current flowing to cranking motor, due either to cranking motor or cranking motor switch being open.

The preceding checks give only an approximate idea of the source of trouble, so in an emergency it might be possible to effect a temporary repair to allow temporary operation. To make a systematic analysis of the cranking motor system, the first step would be to check battery specific gravity. Then the battery connections and cables should be checked, along with cranking motor switch.

If all these are in order, remove cover band and inspect brushes and commutator. The brushes should form good contact with commutator and commutator must be reasonably clean and smooth. If it is not, it should be cleaned or turned down in a lathe. If there are turned bars on commutator, it may indicate open-circuited armature coils which will prevent proper cranking.

If leads have been thrown out of armature slots, indication is that the overrunning clutch caused armature to spit at excessive speed due either to a defective clutch or to the fact that the operator was using improper starting procedure. If the operator opens the throttle too wide on initial starting, or keeps starter pedal depressed too long after the starting has been accomplished, the overrunning clutch may overheat and partially bind so armature is spun at excessive speeds. In addition to damaging the armature, the overrunning clutch also will be ruined by such abuse. Evidence of excessive overrunning of clutch is failing of bearings, depositing of bearing material on armature shaft, and a smooth face in collar on side closest to pinion.

Tight, dirty and worn bearings, bent shaft or loose pole shoe screws which allow armature to drag will reduce armature speed or prevent armature from turning.

If brushes, brush spring tension, commutator, etc., all appear in good condition, it will be necessary to remove the cranking motor for further tests.

Ground Connections of Cranking Motors

In cases where recommended two-wire system is not used on cranking motor circuit, ground wire should go directly from positive terminal to steel frame members and be grounded as shown in Fig. 13-1-7. The motor mounting surface should not be used for ground circuit since pads on flywheel housing must carry this current to the frame, and they may have paint or other highly resistant material on them.

type, but tests have proved that they will engage also
Dyer-type ring gears without damage to gear teeth. Th
due to the type of engagement action peculiar to the S
Clutch used in this class of cranking motors.

Matching Flywheel Ring Gears and Cranking Motors

Figure 13-1-9 illustrates the importance of matching drive pinion and flywheel ring gear teeth properly. The left view shows the action of an overrunning clutch or Bendix pinion as it engages with the correct type of ring gear. However, if a Dyer drive is used with a ring gear for an overrunning clutch or Bendix drive (center view), difficulty is likely to be encountered in engagement. In this case, when the teeth butt, the pinion must move back and up as shown by the arrows before engagement can take place. It must be remembered that, with the Dyer drive cranking motor, pinion movement for engagement is in one direction while pinion movement during cranking is in opposite direction.

The action of a Dyer drive pinion engaging with a Dyer drive-type ring gear after teeth butt is shown at the right in Fig. 13-1-9. It will be noted that the chamfer on ring gear teeth used in connection with a Dyer drive cranking motor must be the reverse of the chamfer on a ring gear used with an overrunning clutch or Bendix drive. If the wrong type of gear is used, repeated attempts will be required for engagement, and burring of teeth is likely to occur. The same trouble will result from mismatching pinion and ring gears due to a change of rotation of engine or of cranking motor.

There is one exception to the above rule. Delco-Remy enclosed shift lever design cranking motor with Sprag Clutch can be used with either Bendix or Dyer-type flywheel ring gear. Pinion gears on these cranking motors are Bendix

Batteries

Battery Specifications

1. The batteries listed in Table 13-1-2 are the minimum ca
ities that must be provided to crank engines at mini
engine temperatures expected. Battery capacities
given in ampere-hours.
2. Minimum battery capacities are based on engines wit
externally connected parasitic loads (such as torque
verters, hydraulic pumps, etc.). Any parasitic load th
coupled during cranking must be determined at lo
starting temperature so an equivalent increase can be r
to the minimum bvattery capacity. Cable circuit resist
must not exceed limits. Battery cable siz
based on total cable length (over to starter and bac
battery).

Minimum Engine Temperature

This temperature refers to engine temperature rather
the lowest night-time temperature. As an example, dur
night when the temperature drops to − 10° F. [− 23
for only a few hours, the minimum engine temper
would probably be no lower than 0° F. [− 18° C.]. Th
gine and battery would have to be "cold soaked" wit
shelter at − 10° F. [− 23° C.] for 6 to 10 hours for th
gine, lubricating oil and battery to reach — 10° F. [−
C.].

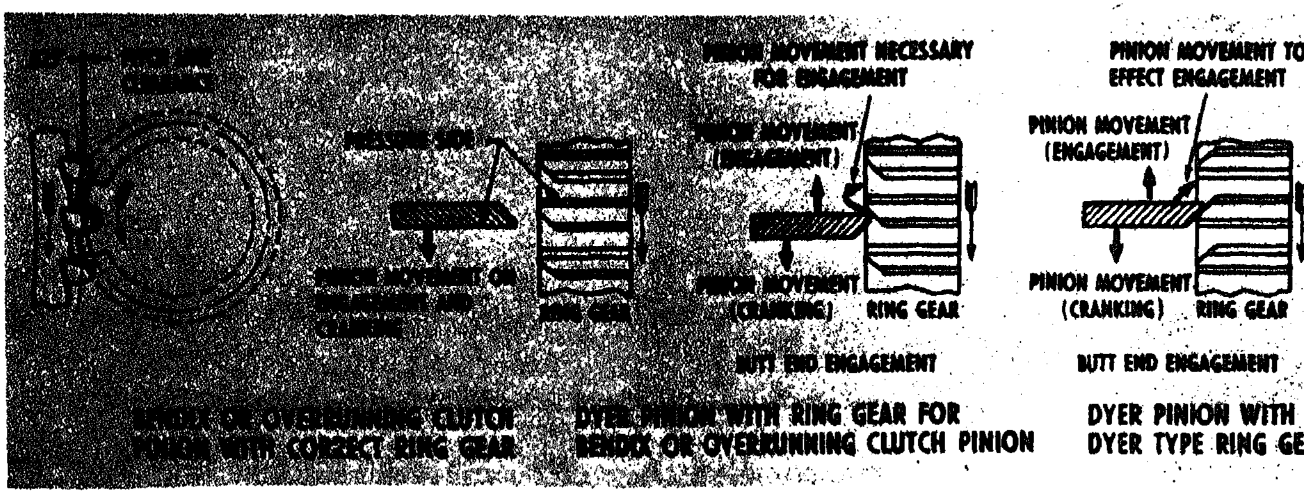


Fig. 13-1-9. Action of Dyer drive-type pinion in engaging with flywheel teeth if different chamfers

Table 13-1-2: Minimum Battery Capacity in Ampere Hours

Cummins Engine Series	Engine Displ. Cu. In.	Winter Climate 0° F. [– 18° C.] Minimum Engine Temperature*		Mild Climate 32° F. [0° C.] Minimum Engine Temperature*	
		12V.	24V.	12V.	24V.
C	Up to 464	340 400**	170	260 300**	100

*"Minimum engine temperature" is the temperature of the engine rather than the lowest night-time temperature. As an example, during a night when the temperature drops to –10°F. [–23°C.] for only a few hours, the minimum engine temperature would probably be no less than 0°F. [–18°C.]. An engine and battery would have to be cold soaked with no shelter at – 10°F. [– 23°C.] for 6-10 hours for the engine lubricating oil and battery to reach – 10°F. [– 23°C.]. All minimum capacities for batteries are based upon using recommended lubricating oils which are SAE 10W for winter climate and SAE 20 for mild and warm climates.

***Minimum capacity shown is for 12-V high output type starters only.*

Table 13-1-3: Ampere Hour Capacity Ratings of Battery Systems

System Voltage	Battery Connections			
24 Volt			Two — 12-Volt Batt. in series	
*Battery AABM Group Size	Total ampere hour system rating at the indicated voltage			
3H	130	260		
4H	150	300		
5D	165	330		
7D	200	400		
9D	340	680		
4D			150	300
6D			165	330
8G			175	
8D			200	400

Association of American Battery Manufacturers

Lubricating Oil

All minimum capacities for batteries are based upon the use of SAE 10 lubricating oil for winter climate and SAE 20 for mild and warm climates, and with no externally connected parasitic loads such as torque converters, hydraulic pumps, etc.

Select the battery system from Table 13-1-3 that will give the required ampere-hour capacity as indicated in Table 13-1-2. In most cases more than one system is listed in

Table 13-1-3 that will meet Table 13-1-2 requirements so extra consideration can be given to space requirements, ease of making connections and costs.

U.S. 6TN and U.S. 8T Batteries

For temperatures below 0° F. [− 18° C.] the use of U.S. 6TN (100 AH at 12 volts) and U.S. 8T (200 AH at 12 volts) is recommended. Also, 6TN and 8T batteries may be used wherever battery size and weight are important considerations. Because of their plate construction, the cranking ability above 0° F. [− 18° C.] of a 6TN battery is approximately equal to a standard 150 AH battery, and an 8T battery to a standard 300 AH battery.

Care should be taken when these batteries are used to make sure the ampere-hour rating is sufficient to handle any continuous current demand when the generator is not charging. Allowing this type of battery to be completely discharged repeatedly will reduce its service life materially.

Starter Circuit Resistance Measurement Procedure

Battery circuit resistance can be determined from current and voltage measurements taken while cranking an engine. Cable resistance equals total cable circuit voltage drop divided by the current flowing.

The instruments required are a low-voltage DC voltmeter and a high-current ammeter. The voltmeter should have a scale so one to three volts can be read accurately. The voltmeter should have long leads so they will reach from battery to starting motor. The ammeter should have a scale so 500 to 1500 amperes can be accurately read. High currents are commonly measured by using a calibrated ammeter shunt with a meter to sense current flowing through the shunt. The shunt is a calibrated resistance capable of carrying high currents. The meter then senses current flowing through the shunt in terms of amperes.

Installations Having One Battery Location

1. Insert ammeter shunt in cable circuit so total starting motor current passes through the shunt. The length of added cable, if required in order to install meter shunt, must be kept at a minimum. All connections must be clean and tight, Figs. 13-1-1, 13-1-2 or 13-1-3.

2. Disconnect wire going to fuel solenoid valve so engine does not start during these tests.

3. Measure voltage drop from positive battery post to its respective post on starting motor while cranking engine. To prevent damage to voltmeter, one voltmeter lead should not be connected until engine has begun to should again be disconnected before starting been disengaged. Both voltage and current read be taken simultaneously approximately two se engine has begun to crank. Since high current ing cranking, readings should be taken quickly ing kept to a minimum to avoid cable heating cranking will cause calculated resistance to be

4. Measure the voltage from negative battery pos spective terminal on starting motor while crank gine. As in Step 3, one voltmeter lead should r nected until after the engine begins to crank again be disconnected before the starting mot gaged. Voltmeter and ammeter readings shoul simultaneously approximately two seconds after begins to crank.

5. Calculate total cable circuit resistance by add voltmeter readings and dividing this sum by the the two current readings.

Maximum Resistance Limits

Total cable resistance should not exceed th Table 13-1-1. Since cable resistance to a l limits a starting motor's cranking performanc mum torque, it is quite important to keep cab within the published resistance limits shown. F tions or use of a frame ground are common c cessive circuit resistance.

Generator—Unit 1302

Generator

The shunt generator converts mechanical energy to e' trical energy and supplies current for electrical equipm by replacing electricity consumed from the battery.

The shunt generator requires external current regulatio the form of a current regulator, voltage regulator, and off relay, which control generator output under all ope ing conditions.

Cleaning

Clean the generator thoroughly of all grease and dust. not clean armature and field in a degreasing tank, as damages the insulation.

Commutator

1. If the commutator is dirty, it may be cleaned with a s of No. 00 sandpaper held against it with a piece of wood while the generator is operated. Blow out dust. Ne use emery cloth since emery may imbed and wear brushes rapidly.
2. If the commutator is rough, out-of-round, or has high m it must be turned down in a lathe and the mica under

Lubrication

1. The oil reservoir in commutator end of generator sho be kept filled with light engine oil to the overflow h This usually requires the addition of 8/10 drops of oil e 200 hours.
2. Generators with grease cups should have the grease c turned down one turn every 200 hours. Keep grease c filled with medium cup grease. Do not lubricate excessi since this might allow oil or grease to get on the c mutator where it would gum and burn, thus reducing g erator output.
3. Under normal operating conditions, sealed generators not require additional lubrication between overhaul peri

Connections

1. Check connections and wiring in generator-to-regulato battery circuit. Check pulley nut to be sure it is tight.
2. Make sure the mounting bolts are tight.
3. All generator installations should be checked carefull

The generator mounting pads and mounting surfaces of the bracket and generator frame should be free of paint, oil, grease or any material resistant to electric current. To further complete the ground circuit, the engine should be grounded to the same frame member used to ground the battery by means of a separate metal strap. This procedure must be followed on third-brush-type generators having only one armature terminal, since the positive brushes on these generators are grounded to the generator frames.

Checking and Adjusting Output

The output of the shunt generator is dependent upon the setting of the current regulator.

Normally, if the generator is checked with an accurate ammeter and a fully charged battery is in the circuit, the proper voltage will be developed. Never set output above specified setting as this will result in generator failure.

Checking Inoperative Generator

If generator is not performing according to specifications and the tests outlined in the section on regulators have disclosed that the generator is definitely at fault, it may be checked as follows to determine location of trouble in generator.

No Output

When no output can be obtained from generator, remove cover band and check for sticking brushes, gummed or burned commutator or other causes of poor contact between commutator and brushes. If cause of trouble is not readily apparent, remove generator from engine for further tests and repairs.

Excessive Generator Output

Excessive generator output is usually due to either (a) a grounded field circuit or (b) a shorted field. Check terminal insulation and, if trouble cannot be corrected, Remove generator from engine for further tests and repairs.

Unsteady or Low Output

This condition may result in any generator from:

1. Sticking brushes, low brush spring tension, or other condition which prevents good contact between brushes and commutator.

2. Commutator that is rough, out-of-round, dirty or burned. Dirt in slots or high mica also cause low or unsteady output. With these conditions, commutator should be turned down in a lathe and mica undercut for carbon brushes. Burned bars, of course, indicate an open-circuit armature and corrections outlined above should be made.

Noisy Generator

This condition may be caused by loose mounting or drive coupling. Worn or dirty bearings may also cause noise. Brushes improperly seated may cause noise that can be eliminated by properly seating them with a brush-seating stone. A bent brush holder may cause noise and requires replacement as it is difficult to properly realign a holder.

Polarizing the Generator

1. Battery-charging DC generators must be polarized prior to starting an engine to prevent major damage to the electrical system. Normally, polarization is performed when:

a. The generator has not been polarized before.

b. Generator is removed from the engine to be repaired and then reinstalled.

c. The generator is used on a negative ground system and polarized for use on a positive ground system, or vice versa.

2. Polarization can be checked or performed as follows:

a. Insulate one brush from commutator of generator.

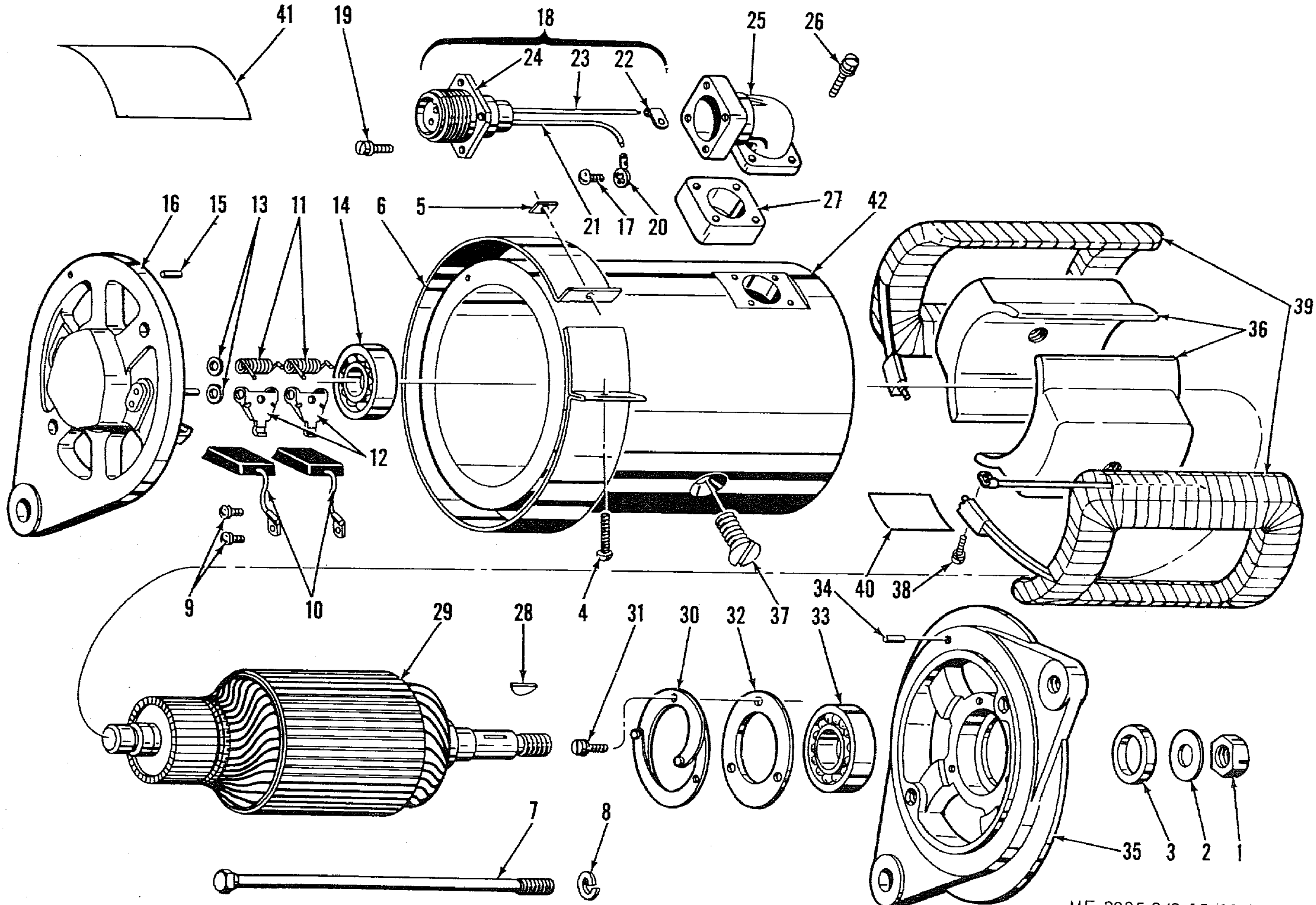
b. Disconnect lead from FIELD terminal of regulator.

c. Momentarily touch FIELD lead to BATTERY terminal on regulator. If there is a small spark, reconnect FIELD lead to regulator and remove insulation from between brush and commutator. The generator is now polarized.

d. If there is no spark, reconnect FIELD lead to regulator and proceed to Step E.

Caution: Never operate generator with field circuits connected and "A" terminal lead disconnected (open-circuit operation), since this would allow a high voltage to build up within generator which would damage fields and armature.

e. Momentarily connect an external jumper between the BATTERY and ARMATURE terminals of regulator. The genera-



ME 2805-243-15/10-9-1

Nut	22	Clip, terminal
Washer	23	Lead
Collar	24	Receptacle
Screw	25	Elbow
Nut	26	Screw and lockwasher
Cover band	27	Spacer
Thru bolt	28	Woodruff key
Lockwasher	29	Armature
Screw and lockwasher	30	Collector
Brush	31	Screw and lockwasher
Spring, brush	32	Plate, bearing retainer
Arm, brush	33	Ball bearing
Washer	34	Dowel pin
Ball bearing	35	Frame, drive end
Dowel pin	36	Pole shoe
Frame, commutator end	37	Screw
Screw	38	Screw and lockwasher
Receptacle assembly	39	Field coil assembly
Screw and lockwasher	40	Insulation
Clip, terminal	41	Insulation
Lead	42	Housing

Figure 13-2-1. Generator, exploded view.

tor is now polarized.

f. Remove insulation from between brush and commutator.

Regulator Controls

Three separate magnetic switches must be used with shunt generator to provide complete control at all times. These are (1) cut-out relay, (2) voltage regulator and (3) current regulator.

Cut-Out Relay

1. The cut-out relay closes circuit between generator and battery when generator voltage has built up to a value sufficient to force a charge into battery.
2. The cut-out relay opens circuit when generator slows or stops and current begins to flow back from battery into generator.
3. The basic wiring diagram for a one-terminal, third-brush current-controlled generator used with a cut-out relay is shown in Fig. 13-2-2. Equipment that requires low generator output, such as shovels and power units, will sometimes have this type of generator and cut-out relay.
4. This type of equipment will give satisfactory service provided the G+ B+ terminal in the relay is properly grounded to the same frame member used to ground battery, as shown in Fig. 13-2-2, and provided the generator is used only for battery charging.

Voltage Regulator

1. The voltage regulator prevents line voltage from exceeding a predetermined value and thus protects battery and other electrical units in system from high voltage.
2. One characteristic of batteries is that, as either the specific gravity or the charging rate increases, other conditions being the same, battery terminal voltage increases. If terminal voltage is held constant as battery comes up to charge (specific gravity increases), charging rate will be reduced. The voltage regulator performs this job of holding voltage constant, and it consequently protects the electrical system from high voltage and the battery from overcharge.

Current Regulator

The current regulator limits generator output to a safe

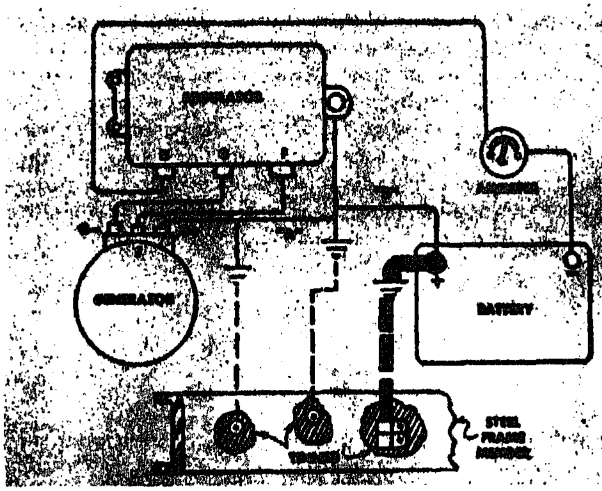


Fig. 13-2-2. Basic generator wiring diagram cut-out relay N1

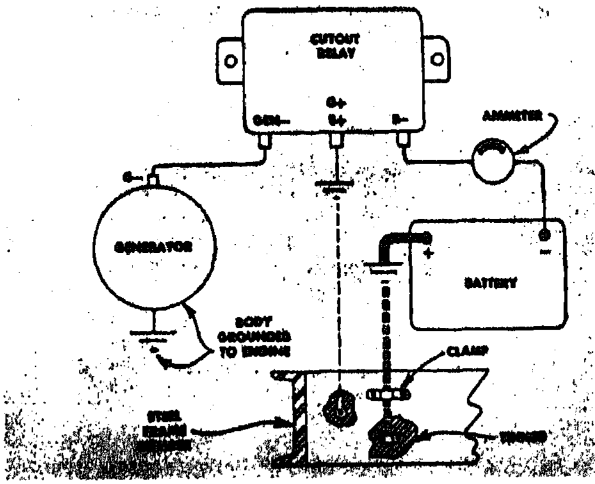


Fig. 13-2-3. Basic generator wiring diagram N

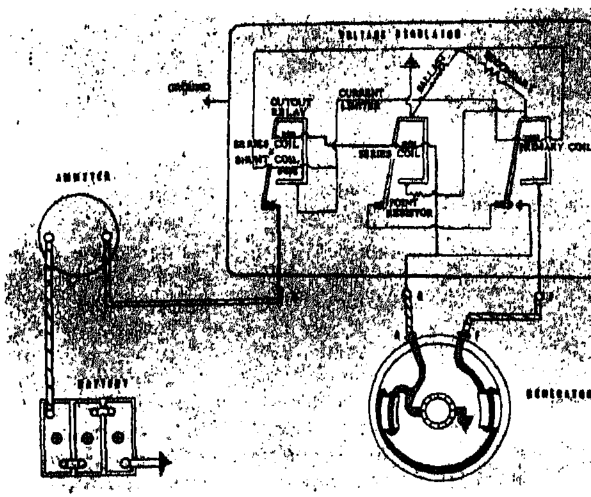


Fig. 13-2-4. current and voltage regulator wiring circuit N

alue. It is, in effect, a current-limiting device that operates hen generator output has increased to its safe maximum nd prevents generator from exceeding this value.

egulator Operating Voltages

egulators are factory adjusted according to the system in hich they work.

urrent and Voltage Regulator Connections

he basic diagram for Leece-Neville equipment, shown in ig. 13-2-4, includes connection of the so-called "universal" egulator. For satisfactory operation, steel base of regulator iust be grounded as shown because these regulators have mall doughnut-type rubber shock mounts bonded to the ase and depend entirely on this ground strap and capcrews to ground unit.

Vires shown as "A" and "B" in Fig. 13-2-3 indicate alterate connections necessary for recommended two-wire ystem.

ome large voltage regulation control units have cast aluinum bases and covers. These units are not grounded hrough their bases, but by separate wires from insulated erminals. This would be indicated on the unit wiring iagram.

ienerator Cut-in

t is advisable to check cut-in point of generator regulator t idling speed. On engines equipped with low cut-in-type enerator regulator, ammeter will indicate some value of harging when electric load is off. On other generator egulator systems, ammeter will read "O". In either case, mmeter will remain steady. Erratic movement of ammeter ndicates that the regulator relay is cutting in and out freuently and this will cause an electric arc at these connecions. If arcing continues, points will eventually weld toether, which will leave circuit closed at all times. This vill cause an overcharge into the battery during operation and a discharge through the generator when engine is stopped, eventually burning up generator and regulator. To overcome this condition, it will be necessary to increase engine idling speed until ammeter remains almost constant. Ammeter movement may indicate a loose connection.

TESTS, REPAIRS, AND ADJUSTMENTS

Complete instructions for testing, repairing, and adjusting electrical equipment will be found in TM 5-764.

Engine Assembly Group

The engine assembly section covers assembly of all u
and subassemblies to the cylinder block as well as adj
ments prior to engine testing.

Assembly—All Units

Engine assembly, as described in this manual, is with the assumption that all units have been rebuilt or are new and are ready to be assembled. During assembly operations, it is important to closely inspect each unit to make sure nothing has been overlooked during rebuilding. Plugs should be checked for tightness, parts kept clean, openings covered, machined surfaces protected and all parts brought to the assembly area to save time and unnecessary labor.

Application of any type of lubricant should be performed from covered containers and with clean fingers (if so applied) to prevent "building dirt into the engine". The engine owner and the operator have every right to expect good service from their rebuilt engine.

Many operations described in the following instructions apply to engines which have been in service for several years; therefore, review each operation and make sure it applies directly to the engine that is being assembled. Likewise, deviating from certain assembly procedures (as set forth in this group) may be necessary for convenience. If so, simply locate the particular assembly step and follow the instructions indicated. As an example, some locations prefer to install cylinder liners before the crankshaft.

Measurements And Torque Values

All measurements and torque values are given in both U.S. and metric units. Metric units are enclosed in brackets [ ] to make them stand out and prevent improper usage.

Mount Cylinder Block To Engine Stand

Mount fuel pump side of block to Engine Sta
using Adapter Plate

Note: If cylinder liner-to-block clearance has not b
checked according to instructions in Cylinder Block Gr
1, the cylinder liners must be installed at this time
liner-to-block clearance should be checked. However
liner-to-block clearance has been checked, follow assem
procedures beginning with installation of crankshaft.

Crankshaft And Main Bearing Shells

1. Turn cylinder block upside down.
2. Make sure that crankshaft, main bearing shells, main be
ing bores, oil passages, etc., have been cleaned and
spected and that pipe plugs are installed tightly in cra
shaft.
3. If not previously performed, check main bearing bore
alignment. See Cylinder Block, Group 1.
4. Clean main bearing caps and capscrew holes; be sure
liquid and foreign particles are removed.
5. Lay upper main bearing shells in block bores, engag
locking tangs with recesses in block bores, Fig. 14-
Index drilled oil passage holes in block and shells.
6. Coat crankshaft surface of upper main bearing sh
thoroughly with Lubriplate or equivalent hi
pressure grease.

   Note: The use of clean lubricant throughout the eng
cannot be over-emphasized; built-in dirt soon causes
gine failure.
7. Lift crankshaft over cylinder block, using a rope sling
hooks protected with rubber hose; lower crankshaft c
fully into place, Fig. 14-1-2.
8. Check rear web of crankshaft to determine whether o
size thrust rings are to be used. Roll upper thrust rings

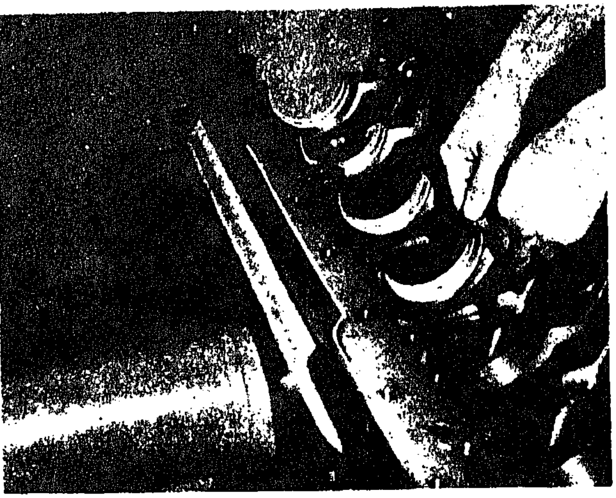


Fig. 14-1-1. Installing upper main bearing shells N21477

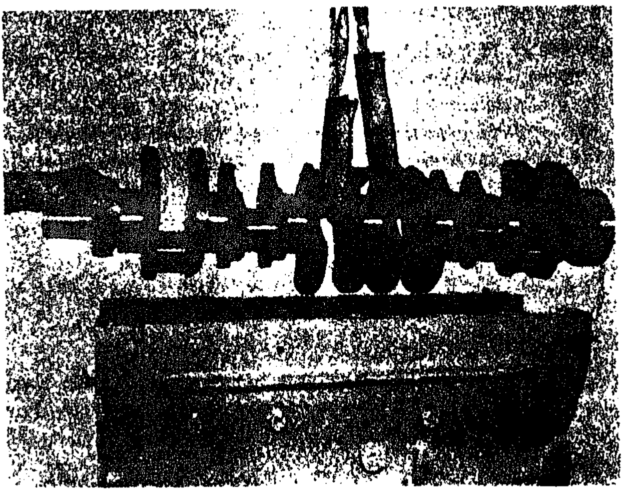


Fig. 14-1-2. Installing crankshaft N21402

position, being certain that babbit or grooved sides are facing crankshaft flanges.

Caution: Worn or reground crankshafts may require oversize (thicker) thrust rings. If crankshaft is not so stamped, check end clearance as described in later paragraphs; then install and mark crankshaft as necessary. Both upper and lower thrust rings must be same size, STD., 0.010 or 0.020 in. [0.2540 or 0.5080 mm].

Note: Upper thrust rings are not doweled to block; doweled lower rings (to main bearing cap) prevent upper rings from turning.

. Coat lower main bearing shells (crankshaft surface) with Lubriplate, or equivalent high-pressure grease; snap lower main bearing shells into place over crankshaft. Lower main bearing shells are plain with no grooves or oil passage holes.

Caution: Solid lower shells should not be used where continuous-groove shells have been used and crankshaft has not been reground.

10. Position lower thrust rings over dowels on No. 7 main bearing cap (1, Fig. 14-1-3) (No. 5 on four-cylinder engines); install main bearing caps with numbers (corresponding to upper main bearings) toward camshaft (fuel pump) side of block.

    Note: Main bearing caps are not interchangeable.

11. Lubricate main bearing capscrew threads with clean lubricating oil; install new lockplates on capscrews.
12. Place main bearing capscrews in position; tighten alternately and slowly to seat caps in position.

    Caution: Driving main bearing caps into position may jar lower main bearing shells out of position.

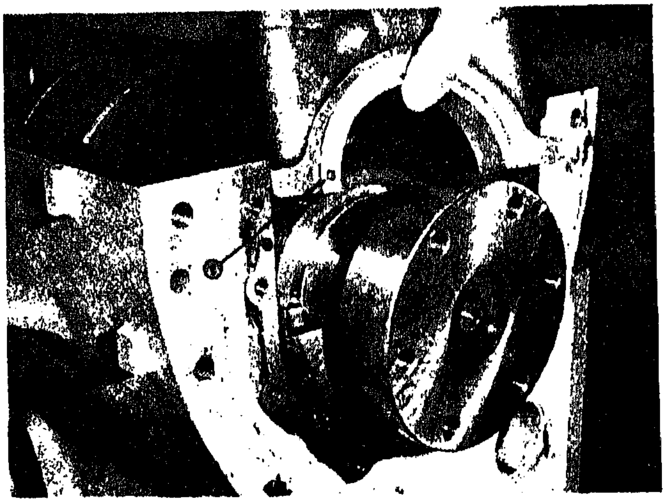


Fig. 14-1-3. Main bearing cap with thrust ring in place N21479

Template Method Of Tightening Main Bearing Capscrews

1. Tighten main bearing capscrews alternately to 65/75 ft. lbs. [8.9895/10.3425 kg m] to set shells, caps and lockplates; then advance to 140/150 ft. lbs. [19.3620/20.7450 kg m], Fig. 14-1-4.
2. Loosen all capscrews completely; tighten to 45/50 ft. lbs. [6.2235/6.9150 kg m] and scribe each capscrew head to coincide with permanent mark on cap, or scribe each cap in line with capscrew hex corner.
3. Advance each capscrew 60° (one hex) from position described in Step 2; this will align scribed mark (or next corner of capscrew) with mark on main bearing cap.

Caution: Tighten capscrews on each side of cap a little at a time and as evenly as possible until proper positions are reached. Never use lead ribbon or feeler gauge to check main bearing clearance. Doing so may result in unnecessary damage to main bearing shells.

Main Bearing Shell Replacement With Crankshaft In Place

If the crankshaft has not been removed from the engine, it is possible to install new main bearing shells in the following manner:

1. Remove one main bearing cap and lower shell; turn crankshaft until drilled hole in main bearing journal is visible.
2. Insert a 7/32 in. [5.5562 mm] by 1/2 in. [12.7000 mm] pin with a head 3/32 in. [2.3812 mm] thick into drilled hole of crankshaft; turn crankshaft so pin pushes against shell on opposite side of locking tang. Shell will turn out as crankshaft is rotated.
3. Carefully remove all metal and/or foreign material from oil passages in crankshaft and cylinder block.
4. Lubricate the shell to be installed; then lay shell in proper position on crankshaft journal so turning the crankshaft will seat the shell locking tang into recess in block.
5. Use pin and turn shell into position; remove pin.
6. Replace lower shell, making sure locking tang seats in recess of main bearing cap.
7. Install new lockplates and position cap against crankshaft; use template method to tighten capscrews. Make sure crankshaft turns freely.
8. If necessary, replace remaining shells one pair at a time in the same manner. If bearing shells have had considerable service, it is recommended that all shells be replaced to assure that the 0.002 in. [0.0508 mm] maximum variation in oil clearance between adjacent main bearing shells and journals is not exceeded.

Check Crankshaft End Clearance

1. Attach dial indicator securely to rear of block with contact point of gauge resting against crankshaft flange end face.
2. Using a small bar (or equivalent), pry crankshaft toward front of block; remove bar and set gauge at "O".
3. Pry crankshaft toward rear of block, Fig. 14-1-5; remove pry bar and read gauge. Total gauge reading should be 0.004/0.015 in. [0.1016/0.3810 mm] with new (or rebuilt) crankshaft and new thrust rings.
4. If reading is less than 0.004 in. [0.1016 mm]:

a. Shift gauge away from crankshaft.

b. Loosen main bearing capscrews slightly.

c. Shift crankshaft first toward front and then toward rear of block in order to properly position main bearing caps.

d. Tighten capscrews, using template method.

e. Recheck end clearance (Steps 1, 2 and 3).

5. When end clearance exceeds 0.022 in. [0.5588 mm], new

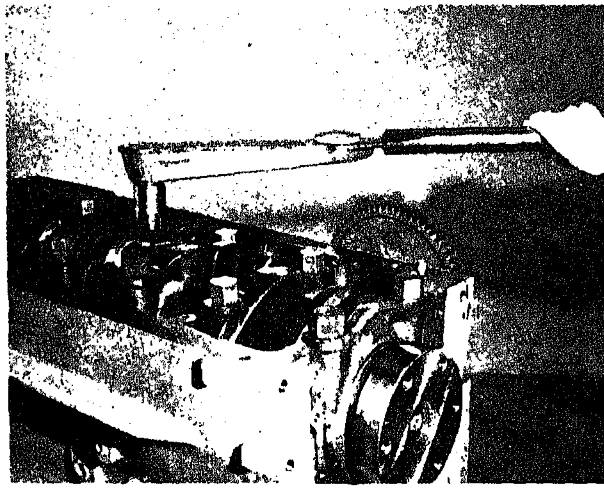


Fig. 14-1-4. Torquing main bearing capscrews N2

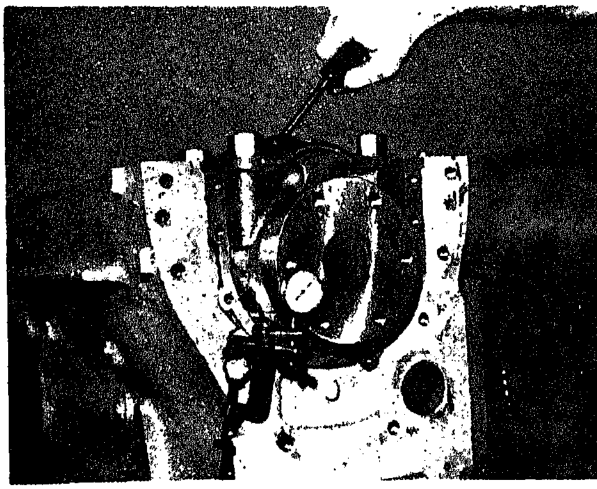


Fig. 14-1-5. Checking crankshaft end play N2

thrust rings and/or crankshaft must be installed.

6. Lock main bearing capscrews by bending lockpla against sides of capscrew heads.
7. Turn crankshaft to be sure it turns freely; if it binds, move crankshaft and recheck for dirt in shells and bore.

Caution: Never ream or scrape main bearing shells.

One-Piece Rear Cover

1. Coat rear cover seal with clean lubricating oil.
2. Install seal into rear cover:

a. Use a flat plate, larger than outside diameter of seal.

.ay rear cover on arbor press table, mounting face down.

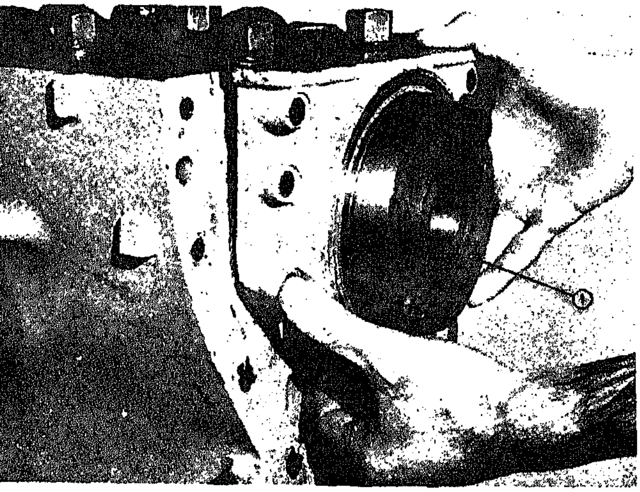
'ress seal ("open" side down) into cover until rear of seal s flush with rear of cover.

.ubricate cavity between oil seal lips with clean lubricat-ng oil.

Clean the crankshaft chamfer outside diameter. A burr on he chamfer would cut the seal and cause a leak.

Position a new cover-to-cylinder block gasket onto cylin-ler block with gasket adhesive.

\ttach Rear Seal Pilot Tool (1, Fig. 14-1-6) to :rankshaft; slide rear cover and seal assembly into posi-ion over tool.



ig. 14-1-6. Installing rear cover N21407

nstall lockwashers and capscrews to secure cover to cyl-nder block; screw in until finger tight.

Shift cover until oil pan surface of cover is flush with oil ban surface of cylinder block, Fig. 14-1-7.

To check rear cover alignment, mount indicator on crank-haft end with point of indicator on machined surface of ear cover trunnion (1, Fig. 14-1-7). Rotate crankshaft and :heck alignment; total indicator runout must not exceed .005 in. [0.1270 mm].

Tighten mounting capscrews to 20/25 ft. lb. [2.7660/3.4575 :g m].

Two-Piece Rear Cover

Clean crankshaft thoroughly with crocus cloth to smooth ough surfaces in seal area. Wipe with clean cloth.

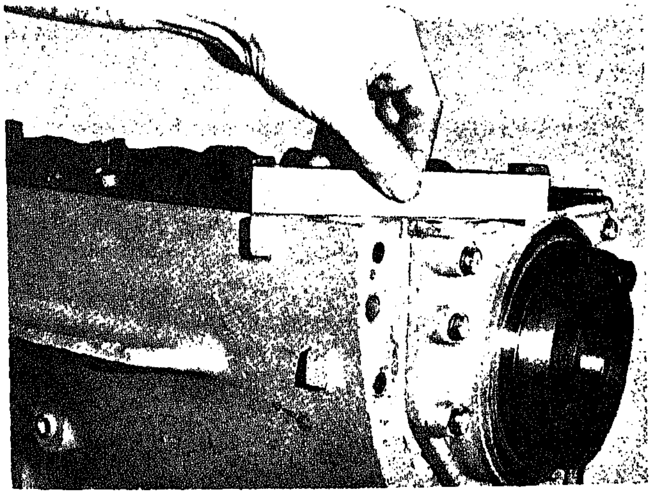


Fig. 14-1-7. Checking cover-to-block alignment N21408

2. Hook spring from oil seal around crankshaft rear cover journal with needle-nose pliers. Do not stretch spring.
3. Apply clean lubricating oil to seal area of crankshaft and oil seal.
4. Assemble oil seal to crankshaft with lip side (grooved or spring side) toward block and "split" toward top of block.
5. Roll spring into position inside oil seal groove.
6. Make sure seal lip has no cuts or creases which would prevent sealing.
7. Cement new gaskets to joining surfaces of upper half of rear cover with gasket adhesive.
8. Cement a new gasket to block with gasket adhesive.
9. Install lower half of rear cover; snug-tighten capscrews to keep cover from slipping.
10. Check alignment of milled surface of bottom of lower half with bottom surface of block. Clearance between crank-shaft and rear cover with crankshaft in extreme rear posi-tion should be 0.004/0.006 in. [0.1016/0.1524 mm]. Install ad-ditional gaskets as required to obtain clearance.
11. Assemble and tighten upper and lower rear cover halves together with two dowel-fit bolts, lockwashers and nuts.
12. Repeat straight-edge check to be sure bottom surfaces of cover and block are in alignment.

Cylinder Liners

1. Check liner counterbore depth in cylinder block at four equidistant points, using Gauge Block, Fig. 14-1-8; "zero" indicator before taking measurements.
2. Measure thickness of cylinder liner flange, outside of bead,

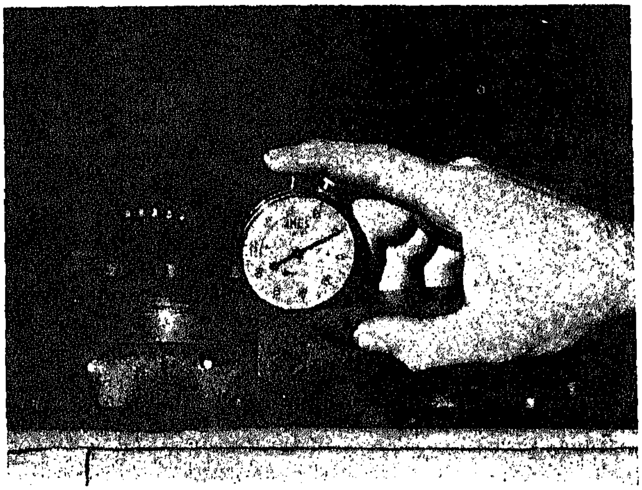


Fig. 14-1-8. Checking cylinder liner counterbore N20103

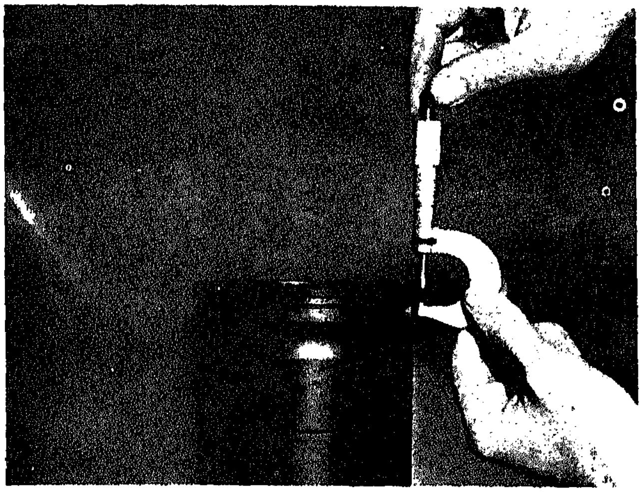


Fig. 14-1-9. Measuring thickness of cylinder liner flange N20104

Fig. 14-1-9. Subtract counterbore depth from liner flange thickness to determine amount of shim thickness required to provide correct liner protrusion above block.

Note: Another method of determining liner protrusion is to install liner in block and measure amount of protrusion (outside of bead) with Gauge Block.

3. Installed cylinder liners must protrude 0.004/0.006 in. [0.1016/0.1524 mm] above block; refer to Table 14-1-1 for required shim(s).

4. If non-press-fit liners are being used (J engines only), check as follows:

a. Install liners without packing rings.

b. Pass a 0.0015 in. [0.0381 mm] feeler gauge around the entire circumference between liner flange and block. If 0.0015 in. [0.0381 mm] clearance is not present, mark binding sp with chalk; remove liner and scrape counterbore at poin of binding until proper clearance is attained.

Table 14-1-1: Cylinder Liner Counterbore Shims

Part No. C	Thickness In.	Thickness [mm]
124107	0.0063/0.0077	[0.1600/0.1955]
124108	0.0072/0.0088	[0.1828/0.2235]
124109	0.0081/0.0099	[0.2057/0.2514]
124110	0.018/0.022	[0.4572/0.5588]
124111	0.028/0.034	[0.7112/0.8636]

5. After determining number and thickness of shims, insta them on liner so they seat at liner flange.

6. Using clean lubricating oil, lubricate surface of cylind block where packing rings and crevice seals will sea wipe off excess oil with clean cloth.

7. Lubricate, with clean lubricating oil, those surfaces on th cylinder liner where packing rings and crevice seal w be located; wipe off excess oil with clean cloth.

8. Assemble liner packing rings and crevice seal on cylind liner in the following manner:

a. Be certain that the correct packing rings and crevice se are selected. (C-engine cylinder liner packing rings a identifiable by a green dot; this liner also takes one cre ice seal

b. Lubricate all packing rings and crevice seals (if used) wi clean lubricating oil; wipe off excess oil with clean cloth

Caution: Never use white lead for lubricating parts. Whi lead will harden and make cleaning difficult during next e gine disassembly.

c. With liner in an upside-down position (skirt end up), sl crevice seal (if used) onto liner and seat in wide groov Fig. 14-1-10.

d. Roll packing rings into position on liner; using mold mar on rings as guides, straighten as required if rings a twisted.

9. Lower the liner into block bore; when packing rings co tact ring-seating bore in block, work liner carefully in downward, circular motion until liner is seated snugly.

10. Using Liner Driver (1, Fig. 14-1-11) and light ha mer, drive liner remainder of distance; when liner is seat firmly, tap driver tool lightly to prevent liner from bounci up again.

11. Check liner bore for roundness at several points with

Fig. 14-1-10. Installing crevice seal N21486

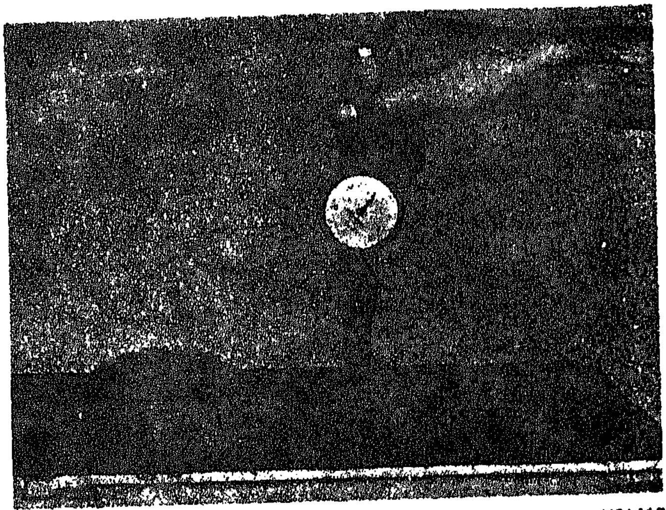


Fig. 14-1-12. Checking cylinder liner bore N21412

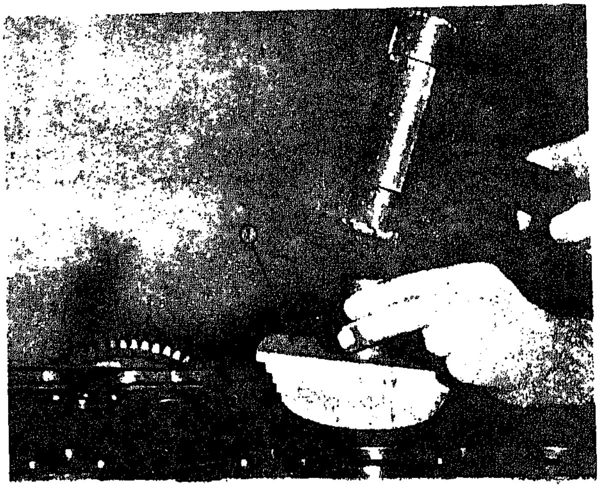


Fig. 14-1-11. Installing liner with Liner Driver N21411

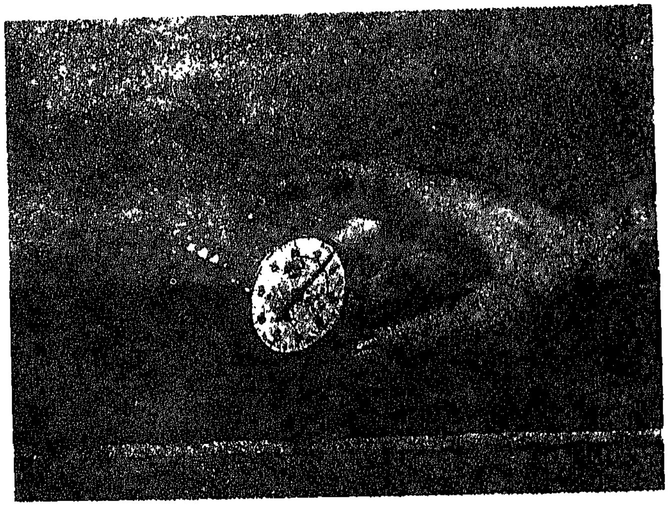


Fig. 14-1-13. Checking cylinder liner protrusion N21413

range of piston travel.

a. Check with a precision dial bore gauge, Fig. 14-1-12.

b. If liner is more than 0.0015 in. [0.0381 mm] out-of-round in packing ring area, remove liner and check for binding condition which would cause distortion of liner bore.

c. A total of 0.003 in. [0.0762 mm] out-of-round at the top one in. [25.4000 mm] of liner bore is permissible if liner is press-fit type.

d. If more than 0.004 in. [0.1016 mm] out-of-round and liner contacts block at packing ring bore, counterbore is out of flat. See Cylinder Block Group 1.

12. Check liner protrusion at four equidistant points with ST-547 Gauge Block, Fig. 14-1-13, to be certain that liner protrusion is within 0.004/0.006 in. [0.1016/0.1524 mm]. Measure outside of bead.

Note: On new liners, lubrite finish may increase readings slightly. Take readings at 60°/75° F. [16°/29° C.]. See Group 16 "Wear Limits"

Installing Two-Valve J-Engine Pistons in Liners From Bottom

If Piston Ring Compressor is not available, piston and connecting rod assemblies (See PISTONS AND CONNECTING RODS) must be installed at skirt end (bottom) of liner after liner bore is checked.

1. Lubricate pistons, rings and liner bore with clean lubricating oil before assembling.

2. Be certain that piston rings are in proper position (spaced

so gaps are not in line).

3. Using the standard   Piston Ring Compressor, install piston and rod assemblies into skirt end of liners.

4. Install liner-piston-rod assemblies into block bores in the same manner as liner installation without piston and rod assemblies (liner bore cannot be checked after installation). Liner valve recesses must be aligned longitudinally on center line of block; numbered side of rod must face camshaft side of block.

Pistons, Rings And Connecting Rods

1. Check all pistons (for any one engine) to make sure they are the same part number, or are compatible as a set when different part numbers are used. Refer to engine parts catalog.

2. Check all connecting rods and caps to be certain they are properly stamped and mated.

3. Check weight of all connecting rods. Actual weight of each rod assembly (which includes bushings, bearing shells, bolts, nuts and lockplates) must not vary more than .03 lb. [0.0136 kg] among all assemblies in any one engine.

4. Heat aluminum piston in boiling water and push piston pin through piston and connecting rod before piston cools, Fig. 14-1-14.

Caution: Never drive piston pin into piston, as this may distort piston enough to cause seizure in liner. Do not overheat pistons (220° F. [104° C.] maximum).

5. Secure piston pin at each end with snap rings; snap rings must be seated in grooves of piston.

6. Check side clearance of rod (piston pin end) to piston boss with feeler gauge; clearance must be 0.040/0.050 in. [1.0160/1.2700 mm].

7. Before installing rings on pistons, lubricate rings and tons with clean lubricating oil.

8. Install piston rings, using   Ring Expander
Fig. 14-1

9. All rings must be installed with the word "Top" toward of piston. Compression rings are placed in upper groo usually the top ring is chrome plated; oil rings (which be multiple-piece assemblies) are placed in lower gro

10. Stagger ring gaps so they are not in line with each o or with piston pin holes in pistons.

Caution: Never use chrome-plated rings in chrome-pla cylinder liners.

11. Remove "U" bolts and cap from one connecting rod sembly. THESE PARTS ARE NOT INTERCHANGEABL

12. Turn engine to vertical position on engine stand; ro crankshaft until any two crank throws are at bottom-ce position.

13. Compress piston rings with   Ring Compressor

14. Match cylinder number stamped on rod with cylinde block; locate stamped number on rod toward camshaft of engine. Install rod and piston assembly into liner by ping top of piston with wooden hammer handle until pi rings have cleared ring compressor, Fig. 14-1-16.

Caution: Do not turn piston in liner. Support connec rod to prevent scratching or marring liner bore. If breakage is suspected, remove assembly from liner check rings carefully.

15. Moving to bottom of block, grasp connecting rod and to within a short distance of crankshaft (for bearing clearance).

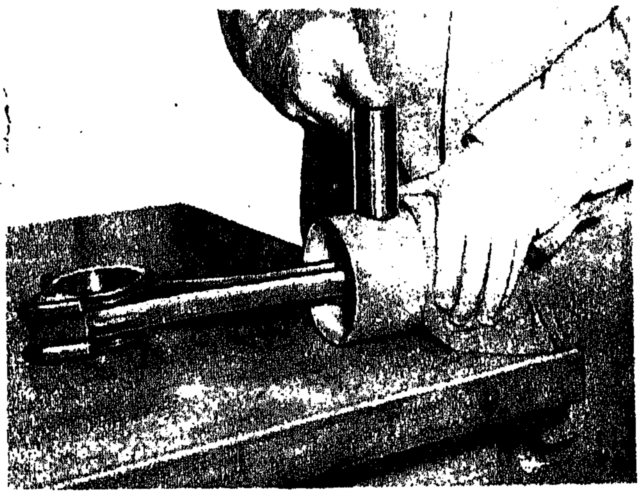
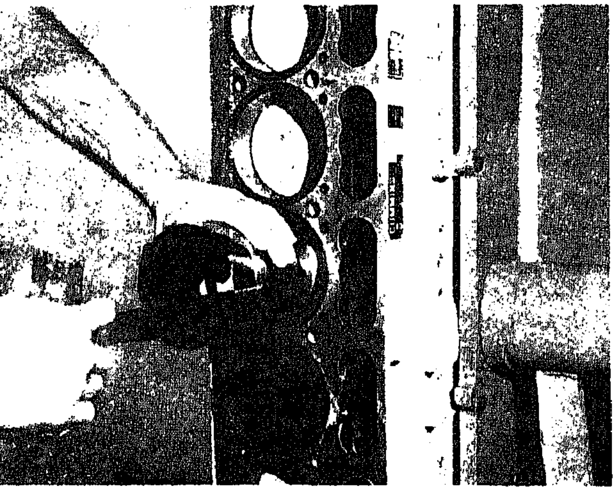


Fig. 14-1-14. Installing pin in piston and rod   N21414

Fig. 14-1-15. Installing piston rings



ig. 14-1-16. Installing piston and rod assemblies N21491

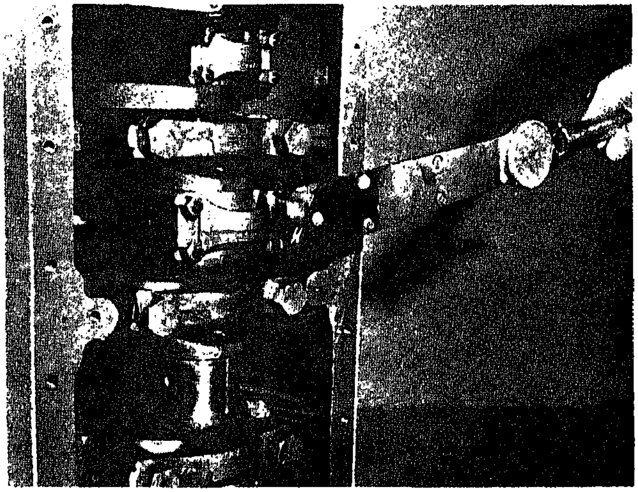


Fig. 14-1-18. Torquing connecting rod "U" bolt nuts N21417

ubricate crankshaft contact surface of upper bearing shell vith a thin coat of Lubriplate,

Slide shell into position between crankshaft journal and od; be sure that shell locking tang makes firm contact vith recess in connecting rod.

Place lower bearing shell in connecting rod cap and lubricate shell with Lubriplate, Be sure that the hell locking tang is seated in milled recess in cap. Cylnder numbers on rod and cap must be on same side and nust match (1 to 1, 2 to 2, etc.). Install "U" bolts on rod; nstall cap to rod over crankshaft journal, Fig. 14-1-17; lubicate bolts, nuts and lockplates and assemble.

Tighten front (of engine) "U"-bolt nuts, then rear "U"-bolt nuts to 15/20 ft. lbs. [2.0745/2.7660 kg m], Fig. 14-1-18.

Bar crankshaft around after each piston and rod assembly

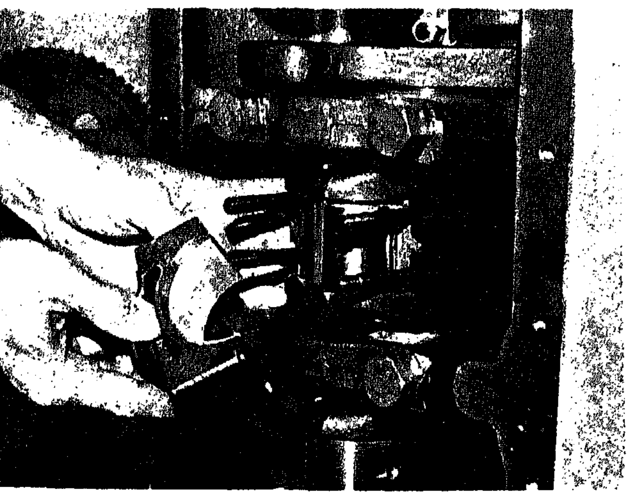


Fig. 14-1-17. Installing connecting rod cap N21416

is installed to see if assembly is binding. After each piston and rod assembly is installed, a little more effort will be required to turn crankshaft; however, if one assembly causes an unusual binding, it indicates an out-of-round liner (probably caused by a misplaced liner packing ring) or an incorrect or misplaced piston ring.

21. Assemble and install each piston and rod assembly in foregoing manner; then:
   a. Tighten each nut (first front, then rear) to 30 ft. lbs. [4.1490 kg m].
   b. Loosen all nuts and repeat steps 19 and 21-a.
   c. Advance each nut one-half hex (30°).
   d. Finish tightening by advancing each nut an additional one-half hex (30°).
   e. Check torque in clockwise direction; if less than 38 ft. lbs. [5.1954 kg m] is required to turn nut after tightening sequence is completed, remove "U" bolt(s) and replace with new one(s).
22. Tightened rod should be free to move sideways on crankshaft journal. Check with hand pressure first; tap lightly with soft hammer only if necessary. Check side clearance (between crankshaft journal and side of connecting rod), Fig. 14-1-19; a minimum of 0.008 in. [0.2032 mm] clearance should be present in this area.

   Note: If rod is not free, remove cap and check for improper bearing shell size, burrs, dirt, tang misengagement, etc. before proceeding with engine assembly.

Gear Cover Mounting Plate

1. Be sure old gasket material is removed from mounting plate; position a new plate-to-block gasket on back of plate with gasket adhesive.

2. Mount plate over dowels, Fig. 14-1-20, and secure with lockwashers and capscrews; tighten to 30/35 ft. lb. [4.1490/4.8405 kg m].

Note: On supercharged engines, be sure that the supercharger oil transfer tube is installed on front of plate.

Idler Shaft

If idler shaft is to be replaced, install shaft so oil passage hole indexes with drilling in block; secure with capscrews, tightened to 200/204 in. lb. [2.3000/2.3460 kg m].

Note: On older engine that is machined to take an idler shaft, but does not have one, be sure a capscrew is installed in idler shaft mounting hole that opens into an oil drilling.

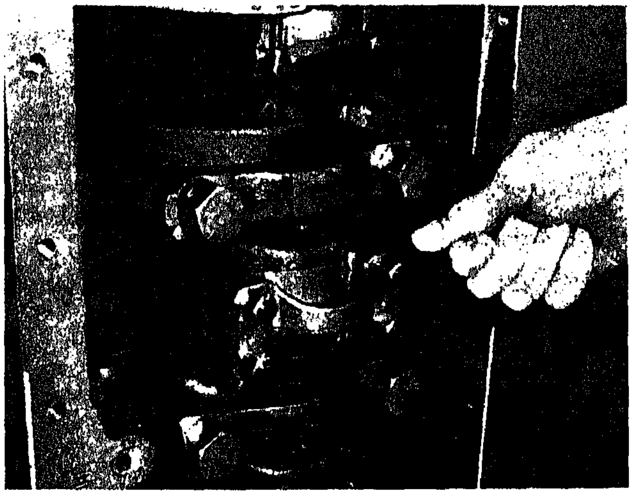


Fig. 14-1-19. Checking rod-to-crankshaft side clearance N21418

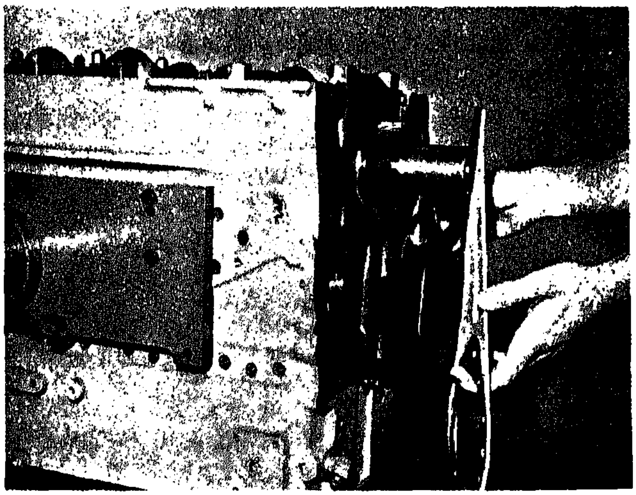


Fig. 14-1-20. Installing gear cover mounting plate N21419

Camshaft

1. Lubricate all camshaft bushings (in block) with Lubri Type 130AA.

2. Rotate camshaft during installation to allow lobes to through bushings easily.

3. Index "O" on camshaft gear with "O" on crankshaft this is Number One top-center firing position.

4. Slide camshaft completely into block; align bearin tainer mounting holes with those in block and secure lockwashers and capscrews through openings in cam gear, Fig. 14-1-21.

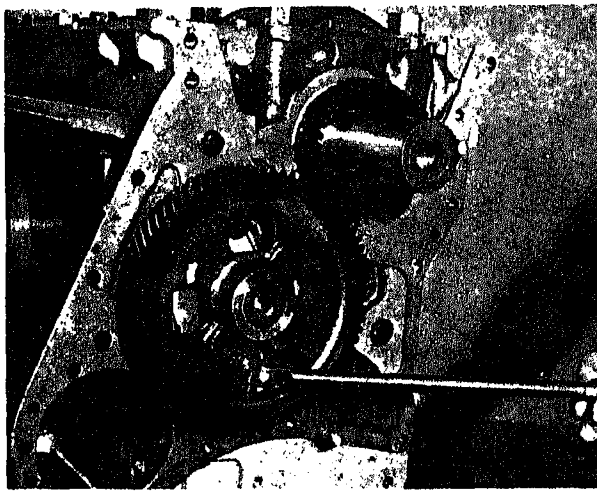


Fig. 14-1-21. Securing camshaft bearing retainer to block

5. Tighten capscrews to 30/35 ft. lb. [4.1490/4.8405 kg m

Supercharger Idler Gear

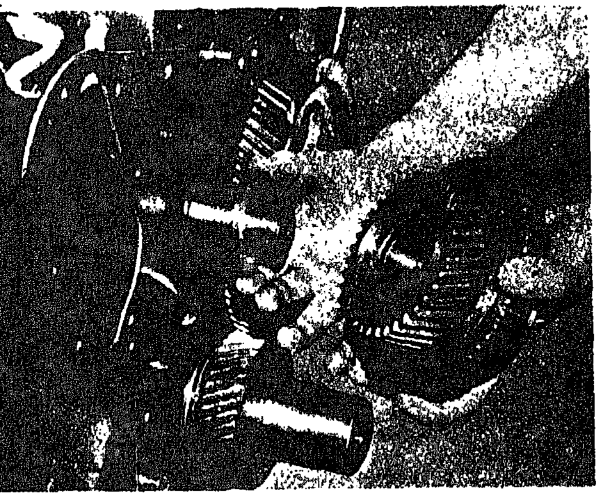
1. Install inner thrust washer on idler shaft, Fig. 14-1-2

2. Place combined supercharger idler gear and driven on idler shaft.

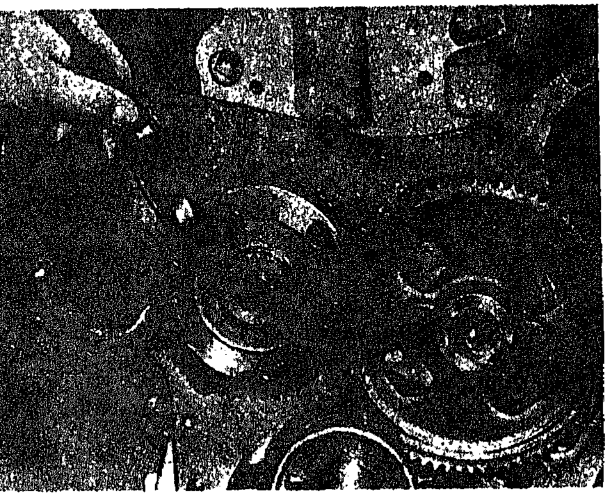
3. Fit outer thrust washer against gear hub; install gear washer and capscrew; secure in place on end of shaft.

4. Check clearance between outer thrust washer and gear, Fig. 14-1-23; clearance should be 0.007/0.0 [0.1778/0.4826 mm].

5. Remove capscrew and cover washer; leave thrust v in place against driven gear. Capscrew and cover v will be replaced after gear cover is installed.



14-1-22. Installing thrust washer on idler shaft N21421



. 14-1-23. Checking clearance between thrust washer and gear N21422

ear Backlash

ear backlash is the amount of play between intermeshed ears. Excessive backlash is a good indication that gear(s) /are worn and should be replaced.

acklash of all gears in gear train may be checked with a al indicator gauge or narrow feeler gauge.

hen dial indicator gauge is used, locate gauge so conct point contacts gear tooth; move gear counterclockse against indicator contact point and set indicator at O".

ove gear clockwise against indicator, Fig. 14-1-24; note ading. Repeat checks on four equidistant points on gear.

ormal gear backlash for C six-cylinder engines with

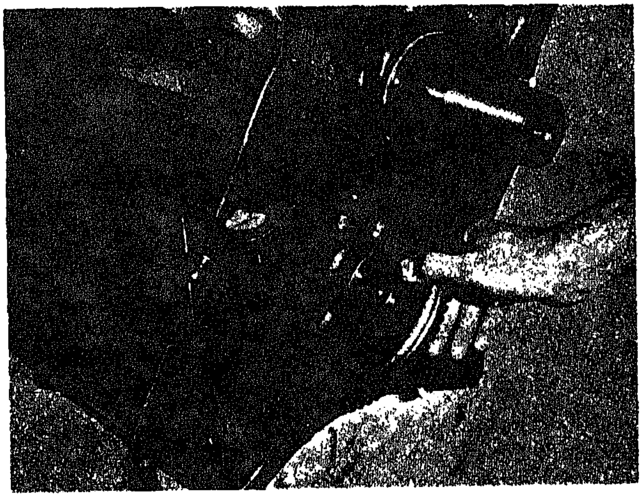


Fig. 14-1-24. Checking camshaft gear backlash N21497

ing gears.

5. Worn gears will naturally have more backlash than new gears and will rattle if backlash exceeds 0.012/0.020 in. [0.3048/0.5080 mm]. If noise is not objectionable, do not replace gear(s) unless backlash exceeds 0.020 in. [0.5080 mm] or unless gear(s) is/are visibly worn.

Caution: Insufficient gear lash or improperly mated gears cause quick gear failure.

Camshaft End Play

1. Secure dial indicator gauge clamp to gear cover plate.
2. Locate indicator pin against front of camshaft gear; pull camshaft and gear toward front of engine as far as possible. Set gauge at "O"
3. Push camshaft and gear toward rear of engine as far as possible; read gauge, Fig. 14-1-25.
4. Proper camshaft end play is 0.007/0.011 in. [0.1778/0.2794 mm]; if clearance exceeds 0.015 in. [0.3810 mm], replace bearing retainer and/or camshaft.

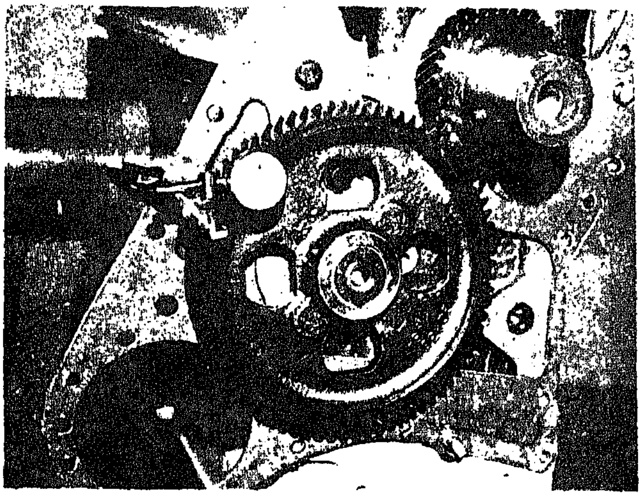


Fig. 14-1-25. Checking camshaft end play N21498

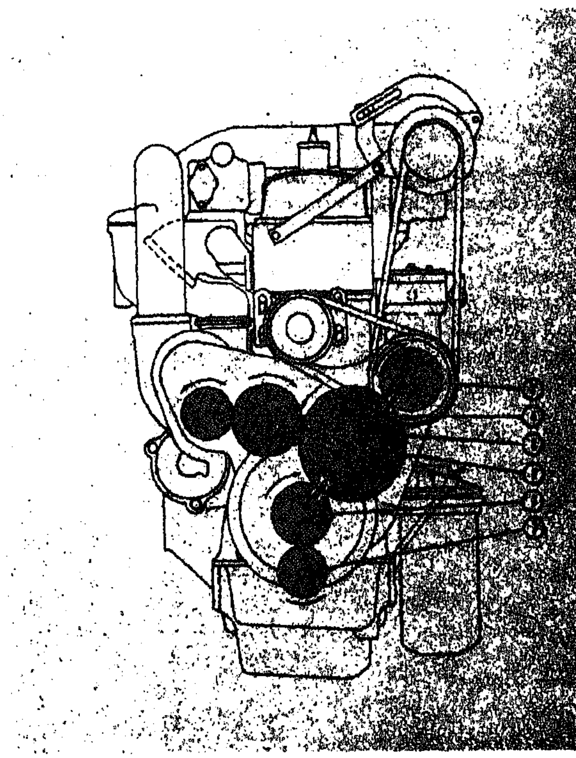


Fig. 14-1-30. Supercharged engine gear train (six-cylinder) N2

Valve And Injector Tappets

1. Install tappets in block; injector tappets are slightly larger than valve tappets and are installed between each pair of valve tappets, Fig. 14-1-33.
2. Align slots in tappet walls with tappet guide screw holes in block.
3. Install tappet guide screws (with nylon inserts), Fig. 14-1-34; tighten to 95/115 in.-lb. [1.0925/1.3225 kg m].

Cylinder Head

1. Cylinder head should have valve guides, valves, valve springs, injector sleeves and plugs in place as described in Cylinder Head Group.

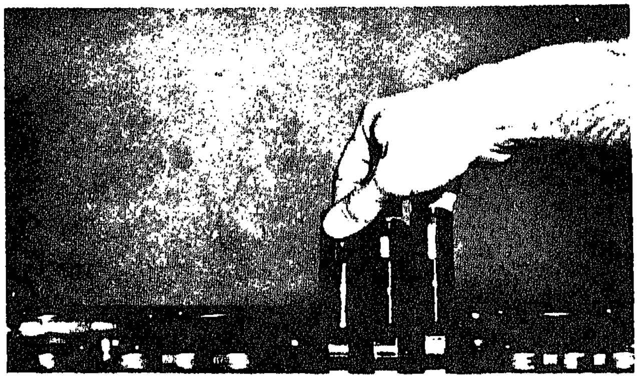


Fig. 14-1-33. Installing tappets N21428

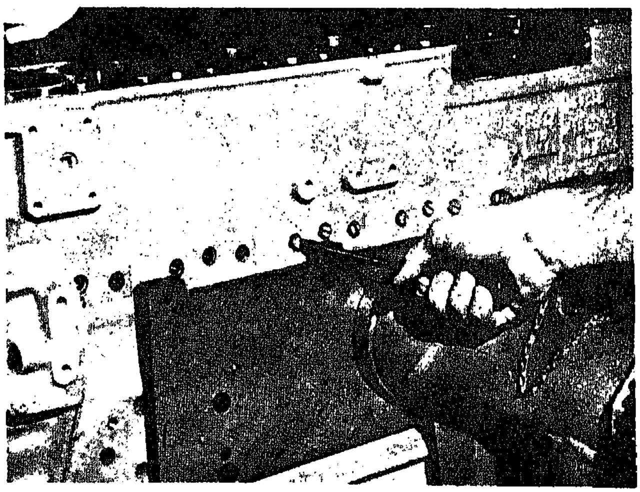


Fig. 14-1-34. Installing tappet guide screws N20020

iear Train Cross Sections

'or information on gear train arrangements, refer to

;upercharged engine gear train, Fig. 14-1-30.

'he following list shows the numbers that indicate each particular gear in gear train cross section figure

ccessory drive gear
amshaft gear
upercharger idler gear
upercharger drive gear
rankshaft gear

il pump drive gear

Dil Slinger

Turn engine right-side-up.

Slide oil slinger onto crankshaft end against gear (cupped side toward block).

Secure slinger to gear with lockplates and capscrews; bend lockplates against capscrew heads.

Clean the mating surfaces of cylinder block and cylinder head; be sure cylinder liner walls are clean and well lubricated with clean lubricating oil.

Be sure all capscrew holes are free of dirt shavings, water, oil, etc.

Place new grommets and new retainers in water passage holes in block, Fig. 14-1-35.

Note: Usually it is most convenient to install retainers in block first and then place grommets on retainers. However, if desired, grommets may be inserted in gasket and retainers may be installed after gasket is laid in place on block.

Install head gasket over dowels, Fig. 14-1-36, being careful not to dislodge grommets and/or retainers; be sure the word "top" is on top side of gasket.

Install one stud (threaded at one end) into each end of cylinder block (or closer together, if desired) (1, Fig. 14-1-37).

Attach Lifting Fixture to cylinder head and lift over cylinder block with suitable hoist; carefully lower head onto cylinder block, using the two studs as guides, Fig. 14-1-37.

Lubricate cylinder head capscrews with Rust Preventive install short capscrews (with hardened washers) into cylinder head and block on exhaust side of head and tighten to 25 ft. lb. [3.4575 kg m] to hold head securely during injection timing.

Checking Injection Timing

Insert an injector push tube into an injector tappet of any

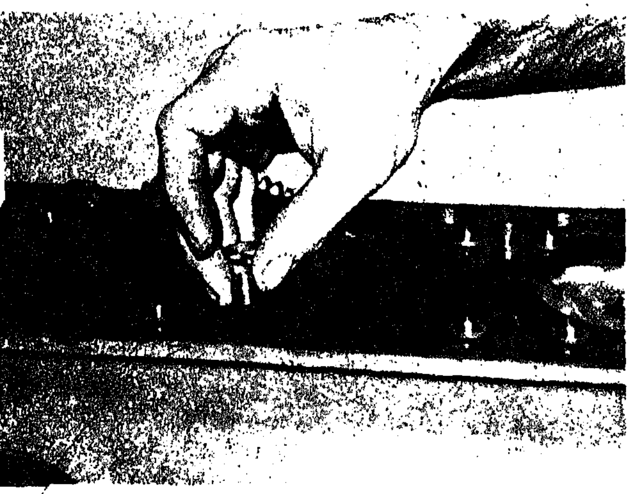


Fig. 14-1-35. Installing grommets and retainers N21429

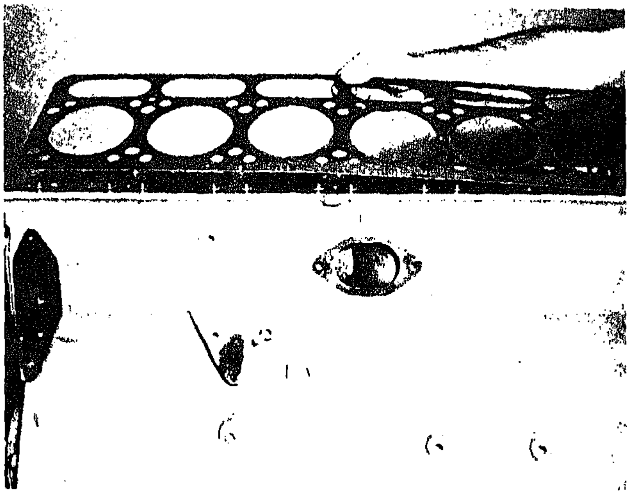


Fig. 14-1-36 Installing cylinder head gasket N21430

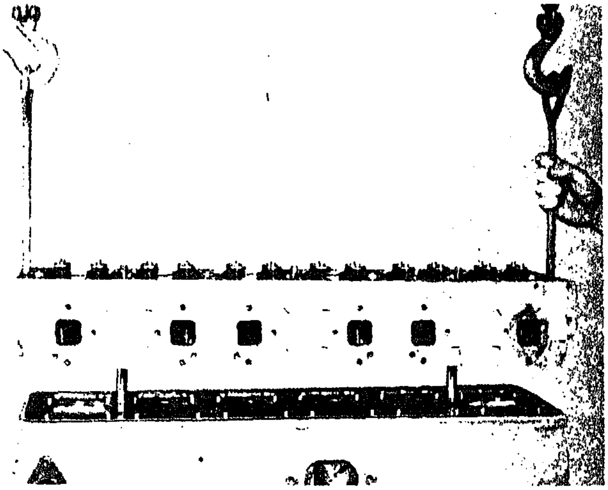


Fig. 14-1-37. Installing cylinder head N21431

cylinder desired; install Timing Tool in injector sleeve of same cylinder by engaging short rod (1, Fig. 14-1-38) in injector push tube socket and securing tool in place with retainers (2, Fig. 14-1-38).

Note: Refer to Fig. 14-1-39 and the condensed instructions following this figure while performing the following steps.

2. Bar engine in direction of rotation to T. D. C. (maximum point of piston rise when both intake and exhaust valves are closed), Fig. 14-1-38. Install indicator above piston within 0.010 in. [0.2540 mm] of fully compressed position. Set indicator dial at "O".
3. Continue to bar engine in direction of rotation until rod reaches 90 mark on left side of tool.
4. Using same method described in Step 2, set indicator above push tube to within 0.010 in. [0.2540 mm] of its fully compressed position; set indicator dial at "O".

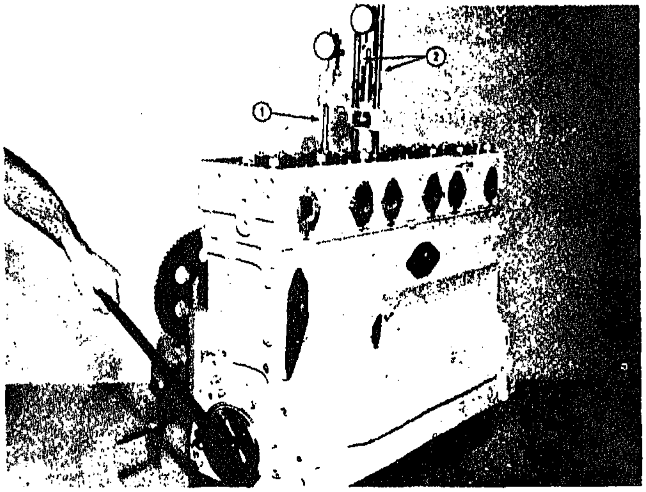


Fig. 14-1-38. Barring engine to check injection timing N21438

Note: Each of the two dial indicators used in timing injection must have total travel of at least 0.250 in. [6.3500 mm].

5. Bar engine in direction opposite rotation to approximately 45° B.T.C.

   Note: The rod over piston will travel up to T.D.C. and then down to 45° mark on left side of tool rod retainer.

6. Bar engine in direction of rotation until indicator above piston reads value under "Piston Travel" in line with 19° B.T.C. in Table 14-1-2. This is 19° B.T.C. or given value in inches lower than top center position. At this point, the indicator above the push tube should match figures shown under "Push Tube Travel" in Table 14-1-2.

7. Continue to bar engine in direction of rotation until indicator above piston reads 12° B.T.C. value under "Piston Travel"; at this point, indicator above push tube should match figure shown under "Push Tube Travel".

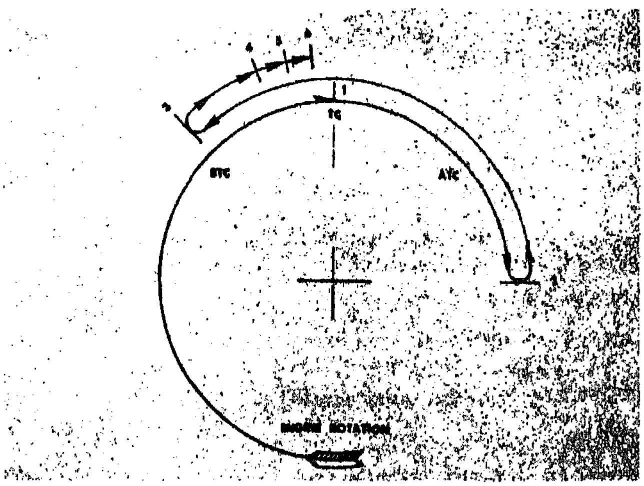


Fig. 14-1-39. Injection timing procedure N11432

Condensed Instructions for Injection Timing

1. Bar engine to top center firing position; set indicator abo piston at "O", Fig. 14-1-39.
2. Advance engine to 90° A.T.C.; top of rod over piston w be at 90° mark. Set indicator above push tube at "O".
3. Bar engine opposite rotation to 45° B.T.C. to take up ge lash; top of rod over push tube will be at 45° mark.
4. Bar engine forward until indicator above piston is at valu opposite 19° B.T.C.
5. Continue to bar engine forward until indicator above pi ton is at value opposite 12° B.T.C.
6. Continue to bar engine forward until indicator above pi ton is at value opposite 5° B.T.C.
7. If values do not match, adjust timing by changing camsha key.
8. Continue to bar engine in direction of rotation until inc cator above piston reads 5° B.T.C. value under "Pisto Travel Inches"; at this point, indicator should again matc figure shown under "Push Tube Travel".
9. If downward travel of push tube (from 90° A.T.C. positio is greater than limits indicated in Table, engine timing slow; if downward travel of push tube is less, timing fast.

   Note: Injection timing may be advanced or retarded by u ing camshaft keys listed in Table 14-1-3. See Group Unit 110, "Camshaft".

Engine Timing Adjustment

1. Remove injector push tube and all tappets; remove cam shaft from block and remove gear and key from camsha
2. Refer to Table 14-1-3 and select required key to adjust e gine timing.
3. Insert key in camshaft, press gear on and install camsha and tappets in block again. See Group 1, Unit 110.

Push Tubes

Push tubes are used to transmit camshaft action to i jectors and valves.

1. Install push tubes in correct tappet sockets.

a. Consult parts book for push tube identification; the i jector push tube goes in the center tappet of each cylind

b. On engines equipped with compression release, inta tubes have collars on them to match with milled recess of compression release shaft; exhaust and injector pu tubes are plain.

On engines without compression release, intake, exhaust and injector push tubes are all plain.

Injectors And Connections

Clean the injector sleeve with a clean cloth wrapped around a wooden stick. Never use a screwdriver or other metal device for this operation; a scratched injector sleeve may cause a compression leak.

Place all injectors in injector bores in cylinder head, Fig. 14-1-40.

Note: When installing injectors in engine, position injector plunger so class marks on plunger sleeves are centered between fuel connection openings. This arrangement provides the same operating conditions as those under which the injectors were tested on Test Stand.

Caution: Be careful not to damage injector cup tips.

3. Start, but do not tighten, hold-down capscrews into injector mounting holes in cylinder head.

4. Place new gaskets on fuel inlet and drain connections; install drain connections in left holes and inlet connections in right holes of injectors.

Table 14-1-2: Injection Timing Specifications

Engine Model Camshaft, Nom. Key	Crank Angle	Piston Travel In.	Piston Travel [mm]	Push Tube Travel Nominal In.	Nominal [mm]	Fast In.	Fast [mm]	Slow In.	Slow [mm]
C-180									
	19° BTC	—0.1711	[—4.3459]	—0.0378	[—0.9601]	—0.0348	[—0.8839]	—0.0398	[—1.0109]
(121580 Camshaft)	12° BTC	—0.0689	[—1.7500]	—0.0234	[—0.5943]	—0.0209	[—0.5308]	—0.0244	[—0.6199]
120602 Key	5° BTC	—0.0120	[—0.3048]	—0.0115	[—0.2921]	—0.0097	[—0.2463]	—0.0127	[—0.3225]

Table 14-1-3: Camshaft Keys

Engine Series	Camshaft Key
C-180	120602 (1½° Retard) arrow toward front of engine

Note: Camshaft and key combination listed above are standard ; however, in rare cases other combinations may be used to bring a particular engine or camshaft into proper injection timing tolerances.

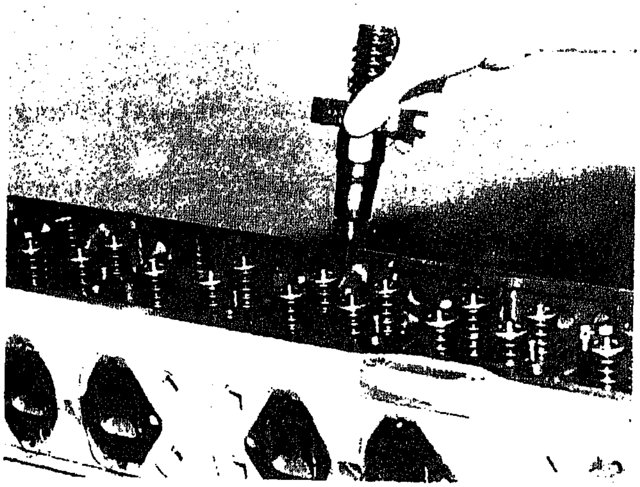


Fig. 14-1-40. Installing injectors N20019

5. Start fuel connections into injectors; approximately three turns are required to align injector body with fuel connections.
6. Tighten injector hold-down capscrews with torque wrench in alternate steps to 12 ft. lbs. [1.6596 kg m], Fig. 14-1-41; begin tightening sequence with capscrew on opposite side of inlet and drain connections.

   Caution: Excessive tightening may distort valve seats or crack cylinder head.

7. Tighten inlet and drain connections to 20/25 ft. lbs. [2.7660/3.4570 kg m], Fig. 14-1-42. Be sure that wrench engages nuts next to connection springs.

Valve Crossheads

1. Install proper (right or left) crossheads on crosshead guides with adjusting screws resting on valves farthest from push tubes (3, Fig. 14-1-43.)
2. If not already done, install valve crosshead retainer under adjusting screw nuts on crossheads; these retainers keep crossheads from jumping off valve stems during engine operation.
3. Use light finger pressure on rocker lever contact surface (1, Fig. 14-1-43) to hold crosshead in contact with valve stem nearest push tubes (2, Fig. 14-1-43); turn crosshead adjusting screw (4, Fig. 14-1-43) down until it contacts valve stem beneath it.
4. If new crossheads and guides (5, Fig. 14-1-43) are used, advance adjusting screws one-third of one hex (20 degrees) to straighten valve stems on their guides and to compensate for slack in threads. When worn crossheads and guides are used, it may be necessary to advance adjusting screws approximately one-half of one hex.

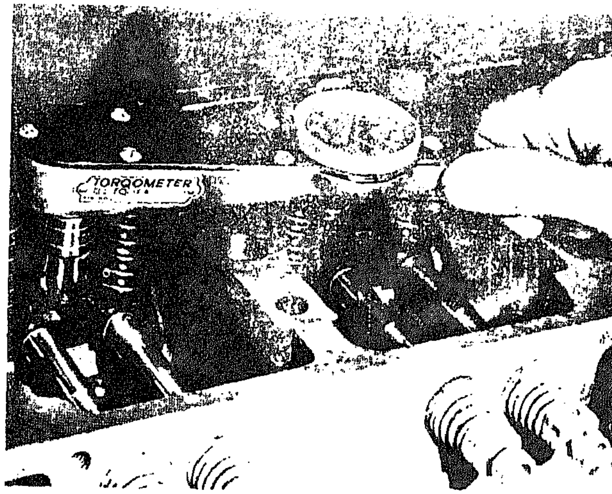


Fig. 14-1-41. Torquing injector hold-down capscrews N2143

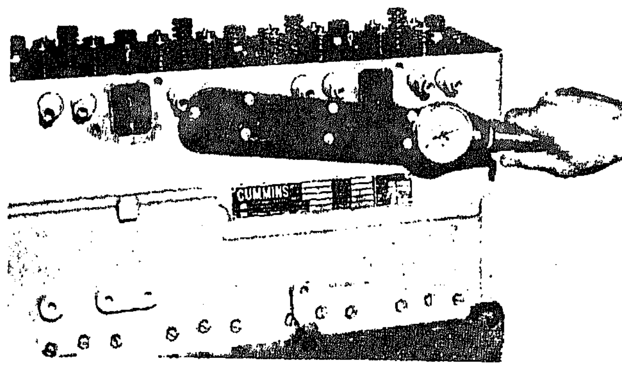


Fig. 14-1-42. Torquing fuel inlet and drain connections N21435

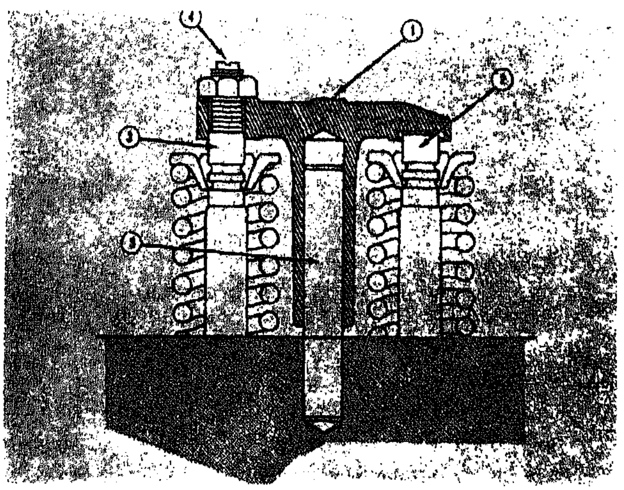


Fig. 14-1-43. Alignment of crosshead stem and guide N21461

Using Torque Wrench Adapter, tighten locknuts to 22/26 ft. lbs. [3.0426/3.5958 kg m], Fig. 14-1-44. If ST-669 is not available, hold screws with screwdriver and tighten locknuts to 25/30 ft. lbs. [3.4575/4.1490 kg m].

Check clearance between each crosshead and valve spring retainer with wire gauge; a minimum of 0.030 in. [0.5080 mm] clearance is required at this point.

Rocker Lever Assembly

Insert oil transfer dowel in cylinder head, Fig. 14-1-45.

Using a bar or wooden slat to hold levers in place, mount rocker lever assembly on cylinder head.

Engage push tubes with rocker lever adjusting screws; drive rocker lever assembly over dowels with soft hammer. Dowels often stick in rocker lever bearing rather than cylinder head.

4. Lubricate rocker lever shaft bearing capscrews with clean lubricating oil; install and tighten securely.
5. Lubricate long cylinder head capscrews with clean lubricating oil; place hardened washers on capscrews and install in cylinder head through rocker lever shaft bearings.
6. Tighten all cylinder head capscrews to 25 ft. lbs. [3.4575 kg m] in sequence shown in Fig. 14-1-46.
7. Continue to tighten capscrews, in 100 ft. lbs. [13.8300 kg m] increments, to 300 ft. lbs. [41.4900 kg m] for ¾ in. [19.0600 mm] capscrews, or to 200 ft. lbs. [27.6600 kg m] for ¹¹⁄₁₆ in. [17.4625 mm] capscrews, Fig. 14-1-47.
8. Then, in 50 ft. lbs. [6.9150 kg m] increments, tighten to

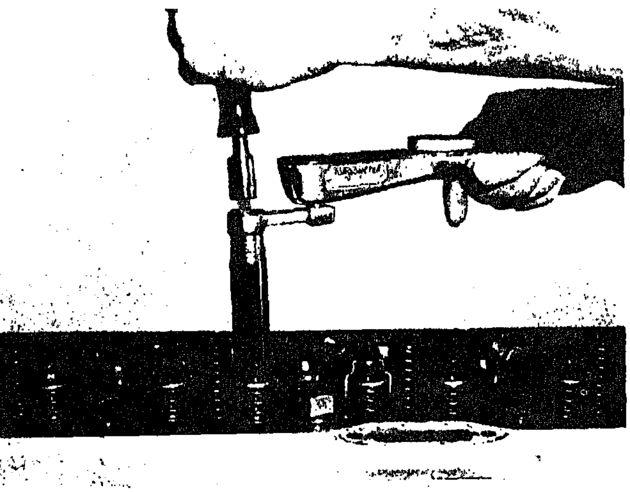


Fig. 14-1-44. Torquing crosshead adjusting screw locknuts N21480

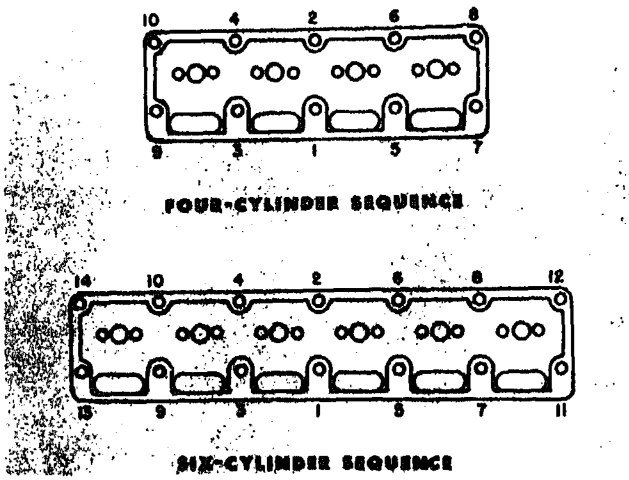


Fig. 14-1-46. Cylinder head capscrew tightening sequence N21437

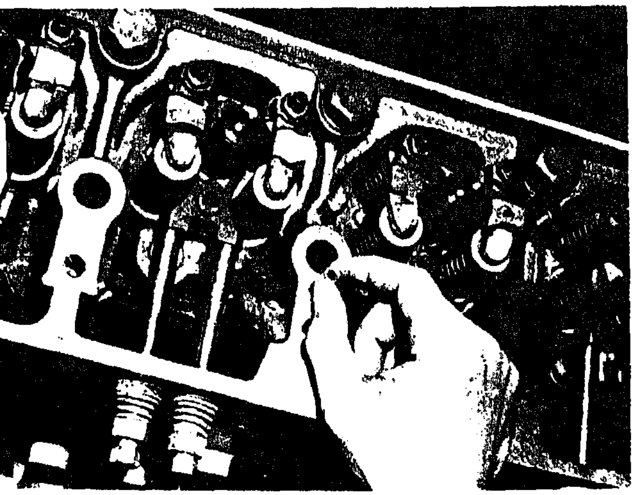


Fig. 14-1-45. Inserting oil transfer dowel N21432

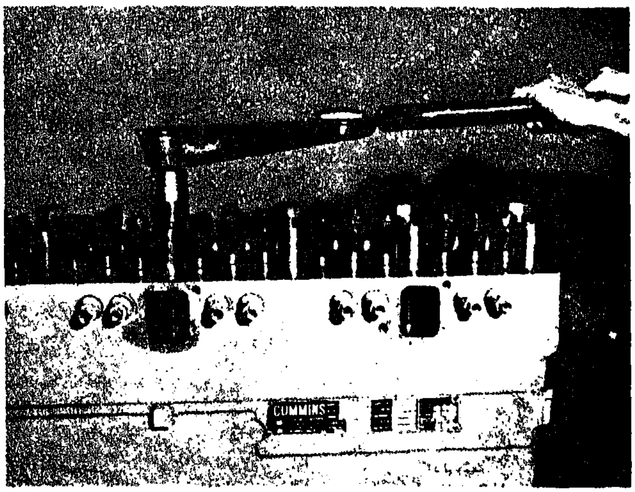


Fig. 14-1-47. Torquing cylinder head capscrews N21481

390/400 ft. lbs. [53.9370/55.3200 kg m] for ¾ in. [19.0500 mm] capscrews, or to 240/260 ft. lbs. [33.1920/35.9580 kg m] for 11/16 in. [17.4625 mm] capscrews.

9. After cylinder head is secured to block, check rocker levers to be sure they are not binding. Tightening the long cylinder head capscrews may shift the rocker lever shaft bearings, causing levers to bind.

10. Binding levers may be freed as follows:

a. Shift one set of injector and valve rocker levers toward rear of engine and against rocker lever shaft bearing.

b. Measure clearance between valve rocker lever and shaft bearing toward front of engine; if clearance is less than 0.009 in. [0.2286 mm], stock must be machined from each side of injector lever to increase clearance to 0.025 in. [0.6350 mm].

c. Check each of the remaining sets of levers in the same manner as "a" and "b" to determine which injector lever(s) must be machined and the amount of stock that must be removed from each side of lever(s).

d. Clean machined lever(s) thoroughly to prevent damage to other engine parts.

Locating New Gear Cover

If the same gear cover is being used that was removed from block, proceed to "Gear Cover Installation." However, if a new gear cover is to be installed on engine, it must be aligned as follows:

1. Remove old dowels from cylinder block. Mount fuel pump drive (compressor drive, if used) to gear cover with lockwashers and capscrews.

2. Secure gear cover to block with lockwashers and capscrews; do not tighten capscrews completely.

3. Fuel pump and compressor drive shaft bore bushings in current gear covers must be aligned by inserting three pieces of 0.002 in. [0.0508 mm] feeler gauge stock at least 1½ in. [38.1000 mm] between bushing and shaft at three equidistant points.

4. On gear covers with roller bearings, attach indicator to crankshaft and check run-out of seal bore; run-out must not exceed 0.010 in. [0.2540 mm].

5. Check bottom surface of cover with oil pan surface of block to be sure they are flush; these surfaces should be within 0.002 in. [0.0508 mm] of being flush.

Caution: Oil seepage will occur if these surfaces are more than 0.002 in. [0.0508 mm] out of flush.

6. Maximum run-out of 0.010 in. [0.2540 mm] total indicator reading is permissible on the following:

a. Crankshaft to crankshaft seal bore.

b. Accessory drive shaft and shaft seal bore.

7. To obtain readings noted in Step 6, attach dial indicato shaft; rotate shaft and read indicator.

8. Ream dowel holes to next oversize, if necessary, and d in oversize dowels. Remove cover from block.

Gear Cover Installation

1. Position new gasket to gear cover with gasket adhesiv

2. Secure gear cover to mounting plate and block with lo washers and capscrews, Fig. 14-1-48. Tighten to 30/35 lbs. [4.1490/4.8405 kg m] torque.

3. On supercharged engines, secure idler gear support wa er and new rubber "O" ring to idler shaft with lubrica capscrew.

Crankshaft Oil Seal

1. Coat gear cover oil seal bore with clean lubricating oi

2. Coat sealing lips and outer diameter of oil seal with cl lubricating oil.

3. Install oil seal in bore with Mandrel and soft ha mer, Fig. 14-1-49. Steel spring side of seal must go i bore first. Drive seal into bore until outer edge of sea at least 0.030 in. [0.7620 mm] inside of bore shoulder.

Note: When installing oil seal in gear cover bore that oil drain holes, space seal out 0.200/0.250 in. [5.0800/6.3 mm] from bore shoulder to keep oil drain holes open.

Accessory Drive Oil Seal

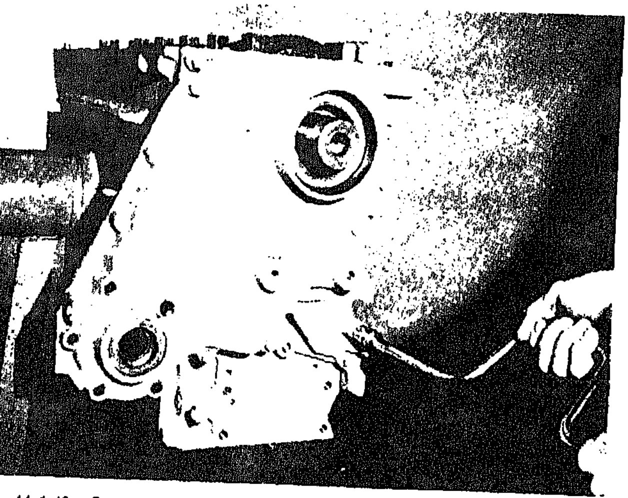
1. Coat sealing lips and outer diameter of oil seal with cl lubricating oil; coat gear cover bore with clean lubricat oil.

2. Install seal by placing a block of wood against back (p no. side) and tapping with hammer until seal is flush w front of cover.

Crankshaft Flange And Vibration Damper

Check viscous-type damper closely for dents and crac Shake damper from front to rear. Movement of loose pie will be felt or heard if fluid has been lost. Tap front face damper at outside and inside seal. If seal is broken a h low sound will be heard at break. If above conditions ex install new damper.

On rubber element dampers make sure alignment marks



. 14-1-48. Securing gear cover to block N21425

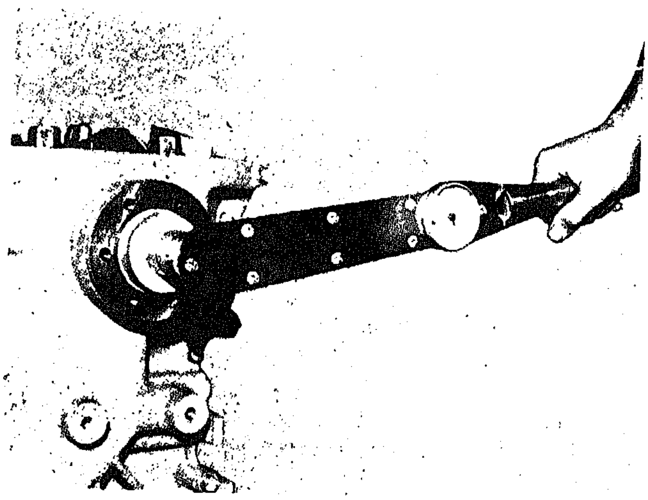
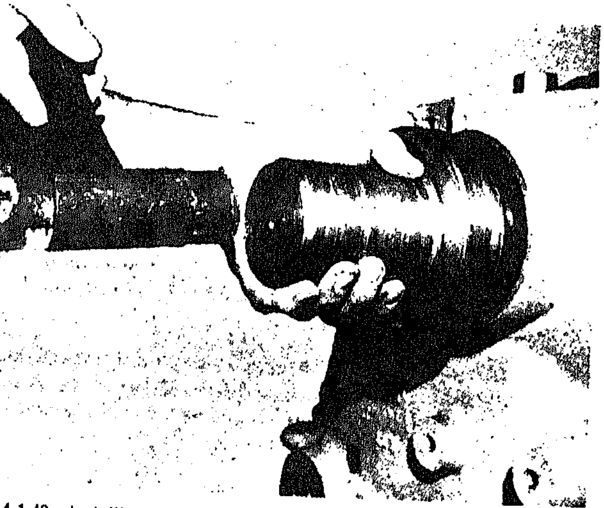


Fig. 14-1-50. Torquing crankshaft flange capscrew N21483



4-1-49. Installing crankshaft oil seal N21482

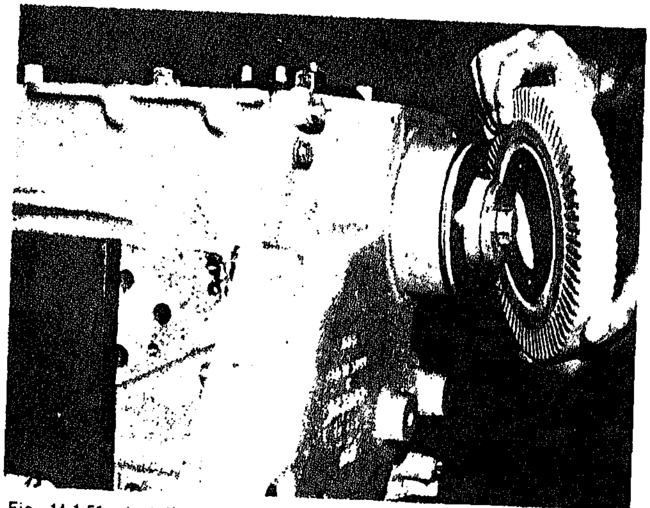


Fig. 14-1-51. Installing vibration damper N21484

netal members are in line.

Iron Flange

flange over crankshaft end; secure with large re- washer and Nylok capscrew (or nut, if used). Torque crew (or nut) to 120/140 ft. lbs. [16.5960/19.3620 kg m], 4-1-50.

vibration damper over flange, Fig. 14-1-51; secure ockplates and capscrews.

e capscrews to 35/45 ft. lbs. [4.8405/6.2235 kg m]; apscrews in place by bending lockplate tangs against rews.

Caution: Do not mount drive pulley (if used) to a cast iron crankshaft flange or to vibration damper.

Steel Flange

1. Mount vibration damper to flange with lockplates and capscrews; torque capscrews to 35/45 ft. lbs. [4.8405/6.2235 kg m] and lock in place with lockplate tangs.
2. Install key (if used) in crankshaft keyway with tapered side down.
3. Mount flange and damper assembly to crankshaft with retaining washer and Nylok capscrew (or nut); torque to 120/140 ft. lbs. [16.5960/19.3620 kg m].
4. If drive pulley is used on crankshaft, mount pulley to crankshaft flange; then mount damper to pulley.

Check Vibration Damper And Flange Run-Out

1. Eccentricity of vibration damper mounting flange measured on the outside diameter of the pilot must not exceed 0.004 in. [0.1016 mm] total indicator reading, (A, Fig. 14-1-52).
2. Wobble in the vibration damper mounting flange must not exceed 0.003 in. [0.0762 mm] measured at $2^3/_4$ in. [69.8500 mm] radius (B, Fig. 14-1-52).
3. After assembly, vibration damper maximum allowable run-out (total indicator reading) must not exceed values shown in Table 14-1-4.

Note: Make checks with dial indicator measured on smooth inner ledge of inertia member. Keep crankshaft thrust clearance to front or rear limit while checking wobble.

Table 14-1-4 — Vibration Damper Run-Out

Part No.	Eccentricity (A) In. [mm]	Wobble (B) In. [mm]
20634-1	0.010 [0.2540]	0.010 [0.2540]
20835-1	0.010 [0.2540]	0.010 [0.2540]
136383	0.030 [0.7620]	0.030 [0.7620]
141654	0.030 [0.7620]	0.030 [0.7620]
142219	0.030 [0.7620]	0.030 [0.7620]

Lubricating Oil Pump

1. Assemble suction tube to oil pump with lockplates, capscrews and new gasket; tighten capscrews finger tight.
2. Attach hanger straps to suction tube bell; screw locknuts to within one turn of being tight.

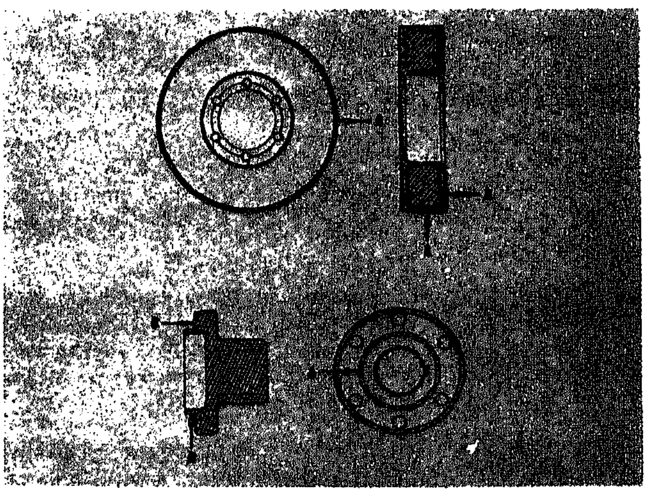


Fig. 14-1-52. Damper and flange eccentricity and wobble N21427

3. Position oil pump, suction tube and hanger straps to blo Fig. 14-1-53; install mounting capscrews and lockpla tighten oil pump capscrews securely and lock lockpla
4. Tighten strap-to-block capscrews finger tight.
5. Tighten suction tube-to-pump capscrews; tighten lockn securing hanger straps to suction tube bell. Tighten han straps-to-block capscrews.
6. Check all capscrews and locknuts; lock all lockplates.

Double Lubricating Oil Pump

1. If dowels were removed, install new dowels for lubricat oil pump.
2. Position oil pump and suction tube assembly on cylin block.
3. Install lockplates and capscrews; secure pump to block.
4. Position brackets on oil suction tube studs; secure v lockplates and nuts.
5. Install lockplates and capscrews; secure oil suction t brackets to block.
6. Position oil drain tube on cylinder block and secure v lockplates and capscrews; bend lockplates into position.

Oil By-Pass Drain Tube

1. Install oil drain tube and bracket on bottom of cylin block on camshaft side of engine; secure tube and brac with lockplates and capscrews.
2. Tighten drain tube flange to cylinder block first; t tighten bracket capscrew to block. This eliminates the p

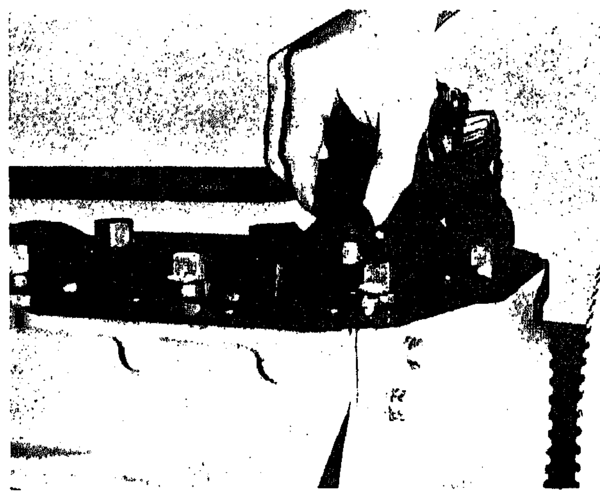


Fig. 14-1-53. Installing oil pump and suction tube N

bility of the drain tube binding between bracket and tube nnge.

Oil Pan

not previously done, install pipe plugs and drain plugs in il pan; position (with adhesive) new gasket on oil pan mounting surface. Check dowels (if used) for worn or oose condition.

osition oil pan to block, Fig. 14-1-54; secure with flat-ashers, lockwashers and capscrews. Tighten capscrews nough to hold oil pan firmly in place.

sing a straightedge, check rear surfaces of block and oil an to be sure these surfaces are flush, Fig. 14-1-55.

ote: Pan must be flush with rear of block to prevent oil eakage and distortion of flywheel housing.

fter checking pan-to-block alignment, loosen all cap-crews mounting pan to block.

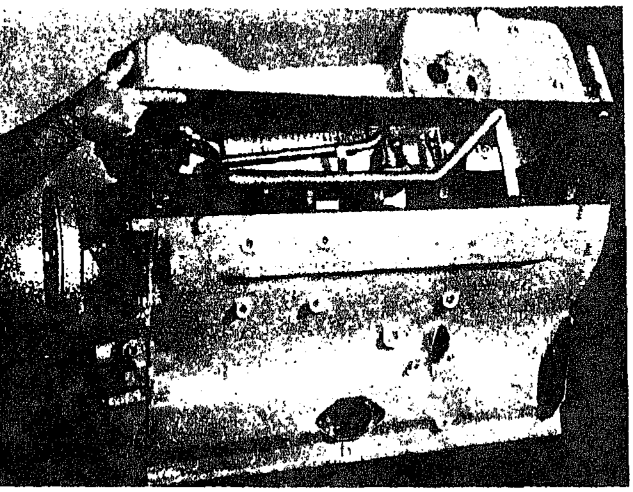
Caution: Oil leakage may occur if oil pan capscrews are ghtened before flywheel housing installation.

Flywheel Housing

Clean dirt and burrs from flywheel housing, cylinder block nd oil pan mating surfaces.

Position (with adhesive) new gasket in camshaft counter-ore of flywheel housing, Fig. 14-1-56. Be sure gasket is et firmly in place.

f new flywheel housing is being used, or if dowels are



ig. 14-1-54. Installing oil pan N20022

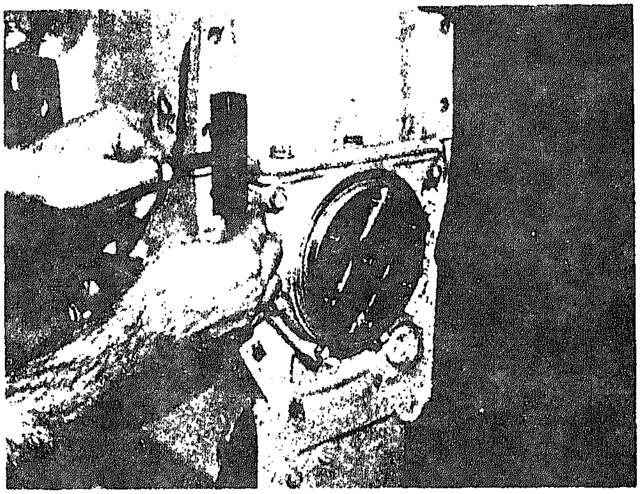


Fig. 14-1-55. Checking pan-to-block alignment N21487

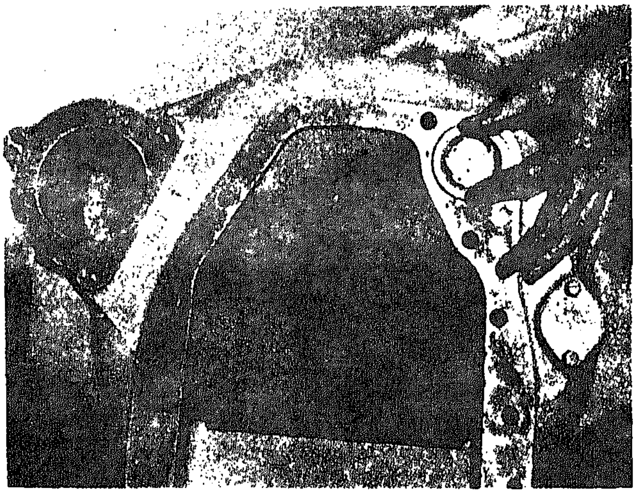


Fig. 14-1-56. Installing gasket in camshaft counterbore of flywheel housing N21452

worn, sheared or loose, replace them with new dowels.

4. **If wet-type flywheel housing is used, install "O" ring seal around rear cover after lubricating the ring with clean lubricating oil. Some wet-type housings have an inspection plate which must be mounted with a gasket, copper washers and capscrews.**

5. **If engine is to be subjected to dusty conditions, install neoprene sponge rubber seal between flywheel housing and oil pan. Seal is available as Part No. 139904 and is equipped with a fabric pull tape or cotter key to facilitate removal of seal (to allow removal of oil pan).**

6. **Mount flywheel housing to cylinder block and oil pan with lockwashers, flatwashers and capscrews; snug-tighten capscrews.**

1. Attach indicator gauge to crankshaft flange, Fig. 14-1-57.
2. Draw chalk marks at A, A[1], B and B[1], Fig. 14-1-58.
3. Check readings at B and B[1]. If total run-out exceeds 0.010 in. [0.2540 mm], use a pinch bar to move housing one-half distance of total indicator reading in order to center housing horizontally.
4. Check readings at A and A[1]. If total run-out exceeds 0.010 in. [0.2540 mm], use a pinch bar to pry housing either up or down, whichever is necessary, one-half distance of total indicator reading in order to center vertically.
5. Check housing bore circumference; total run-out must not exceed 0.010 in. [0.2540 mm].
6. After readings are within limits, tighten capscrews alter-

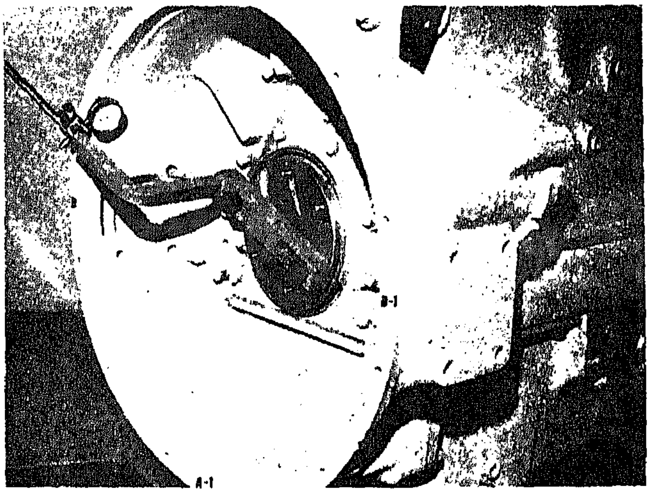


Fig. 14-1-57. Indicating flywheel housing bore N21453

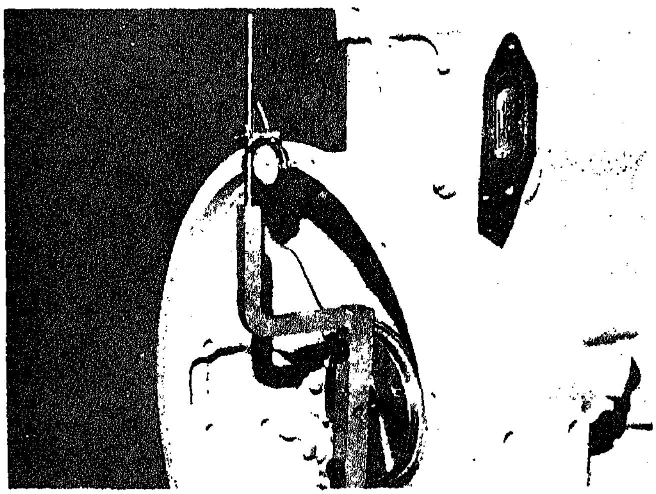


Fig. 14-1-58. Indicating flywheel housing face N21454

and recheck total run-out.

Indicate Flywheel Housing Face

1. Attach indicator gauge as shown in Fig. 14-1-58.
2. Push crankshaft forward to take up end clearance.
3. Turn crankshaft to obtain readings on housing face.

   Note: Take up crankshaft end clearance in same direct each time.
4. Total flywheel housing face run-out must not exceed 0.(in. [0.2032 mm].
5. If both bore and face run-out readings are within limits a dowels were removed, ream dowel holes to smallest p missible oversize with drill ream fixture as d scribed in Step 7.
6. If necessary to correct for housing face run-out after bore has been aligned, remove housing and recheck mat surfaces. Then reinstall, realign and dowel.

   Caution: Be sure all housing capscrews are tight.
7. To use drill ream fixture:

a. Attach plate to crankshaft flange, locating tapered plug former dowel holes.

b. Remove tapered plug; substitute drill and ream bushir

c. Drill new dowel holes. Make sure all metal shavings removed from dowel holes. Ream holes for oversize dow

   Caution: If dowel holes are not pilot-reamed or new dov installed straight, housing will shift and extreme diffic will be encountered at next engine rebuild.

d. Clean out dowel holes and install new dowels.

Tighten Oil Pan Capscrews

1. Install oil pan-to-flywheel housing capscrews and sn tighten in place.
2. Tighten oil pan-to-flywheel housing capscrews and oil p to-block capscrews alternately to "pull" oil pan into cor formed by block and flywheel housing to prevent poss oil leakage.

Flywheel

1. Clean flywheel and crankshaft flange face of all dirt burrs.
2. Inspect dowels (if used); if loose, worn or signs of shea are evident, pull dowels.

f flywheel ring gear is to be installed, heat gear to 600° F. [315° C.] and slip over flywheel. **Do not drive ring gear on flywheel without heating.**

When installing a new flywheel with "O" marks, match "O" indexing marks on flywheel and crankshaft.

nstall two guide studs in crankshaft flange. Assemble flywheel over studs (and dowels) to crankshaft flange.

f dowels were removed, match dowel holes in flywheel and crankshaft.

nsert flywheel washers (if used) and capscrews and tighten alternately to 50/60 ft. lbs. [6.9150/8.2980 kg m]. Using same sequence, tighten flywheel capscrews to final torque of 100/110 ft. lbs. [13.8300/15.2130 kg m].

Note: If self-locking capscrews are not used, lockwires must be installed in capscrew heads.

ndicate Flywheel Bearing Bore

Attach indicator gauge to flywheel housing.

Check clutch pilot bearing bore, Fig. 14-1-59; total run-out must not exceed 0.005 in. [0.1270 mm].

ndicate Flywheel Face

Shift gauge to indicate flywheel face, Fig. 14-1-60.

Draw four equidistant chalk marks on flywheel circumference.

Turn crankshaft, taking up crankshaft end clearance as chalk marks align with indicator. Run-out must not exceed 0.0005 in. [0.0127 mm] per in. [25.4000 mm] of diameter.

f run-out exceeds 0.0005 in. [0.0127 mm] per in. [25.4000 mm] of diameter, remove flywheel and clean flywheel and crankshaft flange mating surfaces.

Reinstall flywheel; check bore at face.

Note: Crankshaft must be kept at front or rear limit of thrust clearance while check is being made.

Torque capscrews to 100/110 ft. lbs. [13.8300/15.2130 kg m].

f capscrews have holes in head for safety wire, install by crosswiring between pairs of capscrews.

Supercharger

Remove masking tape from supercharger outlet port; assemble connecting band loosely in place on outlet port.

Note: Do not remove masking tape from supercharger inlet port until connection is to be mounted.

Check to see that locating dowels (1, Fig. 14-1-61) are in place in gear cover; place a new rubber "O" ring (2) over oil transfer (supply) ferrule.

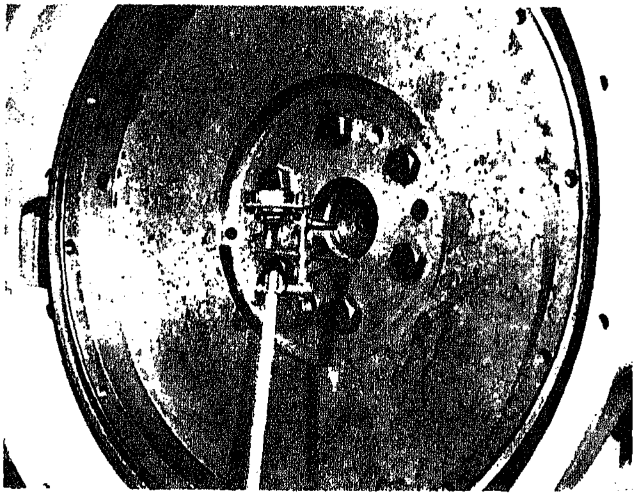


Fig. 14-1-59. Indicating flywheel clutch bearing bore N21456

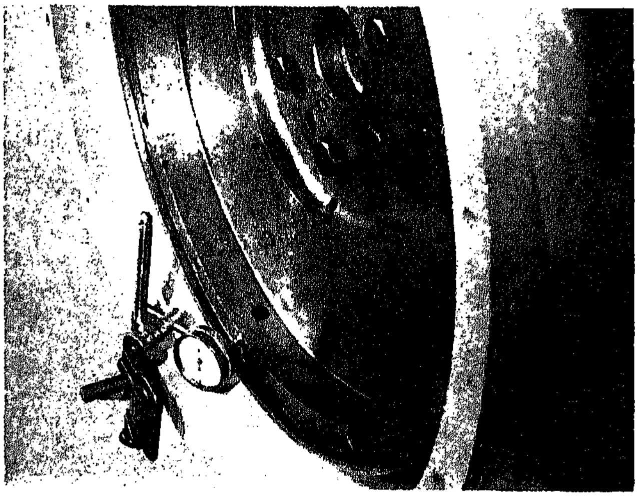


Fig. 14-1-60. Indicating flywheel face N21457

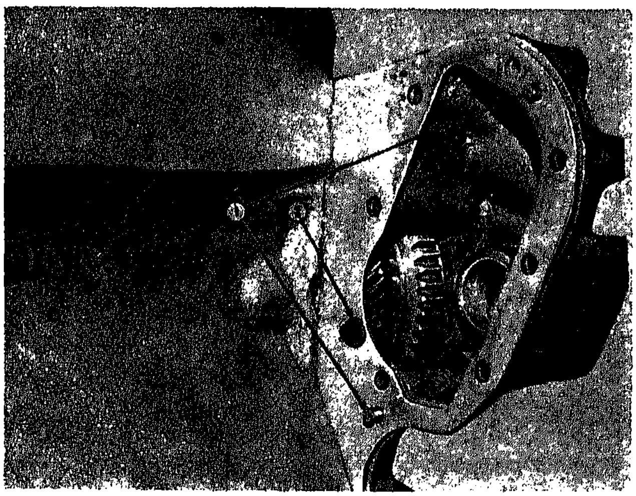


Fig. 14-1-61. Supercharger locating dowels and oil ferrule N21439

3. Position (with adhesive) new mounting gasket to super charger.

4. Lift supercharger to back of gear cover; mesh drive gear with idler gear and secure supercharger to gear cover with lockwashers and capscrews. Tighten capscrews securely.

Supercharger Outlet Connection

1. Install new "O" ring retainer and band on supercharger outlet connection.

2. Position connection over supercharger outlet port; tighten connecting band.

3. Secure outlet connection to block with lockwasher and capscrew.

   Note: Crossover connection will be installed after cylinder head cover is secured to head.

Water Header Cover Plate

Position water header cover plate to side of cylinder block with new gasket; secure with lockwashers and capscrews.

Exhaust Manifold (Four-Valve Engine)

(7/16 in. [11.1125 mm] Dia. Studs)

1. Install gaskets over studs and dowels.

2. Position manifold assembly over studs and dowels; secure with clamps and nuts.

3. Tighten all nuts to 40 ft. lbs. [5.5320 kg m] in 20 ft. lb. [2.7660 kg m] increments.

   Note: If washers or lockplates are used under nuts, maximum torque must be reduced to 25 ft. lbs. [3.4575 kg m].

(3/8 in. [9.5250 mm] Dia. Capscrews)

1. Make sure both manifold dowels are in cylinder head.

2. Install two guide studs into cylinder head at an equal distance from each end of head; slide manifold assembly over guide studs.

3. Insert one gasket at a time, Fig. 14-1-62; install lockplates and capscrews into manifold mounting holes as gaskets are inserted.

4. Remove guide studs, insert gaskets and install lockplates and capscrews; tighten all capscrews to 10 ft. lbs. [1.3830 kg m].

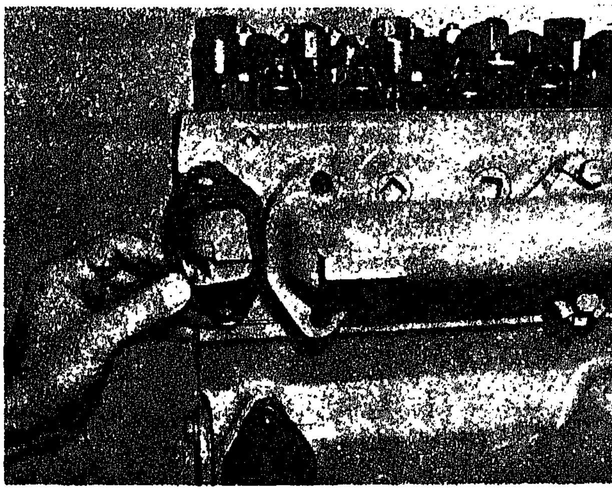


Fig. 14-1-62. Installing exhaust manifold gasket N21

5. Tighten capscrews alternately to 22 ft. lbs. [3.0366 kg m]; lock in place with lockplates.

(3/8 in. [9.5250 mm] Dia. Studs)

1. Install gaskets over manifold studs.

2. Slide manifold assembly onto studs; secure to head with clamps and nuts.

3. Tighten all nuts to 25 ft. lbs. [3.4575 kg m] in 10 ft. lb. [1.3830 kg m] increments; if lockplates are used, lock nuts in place.

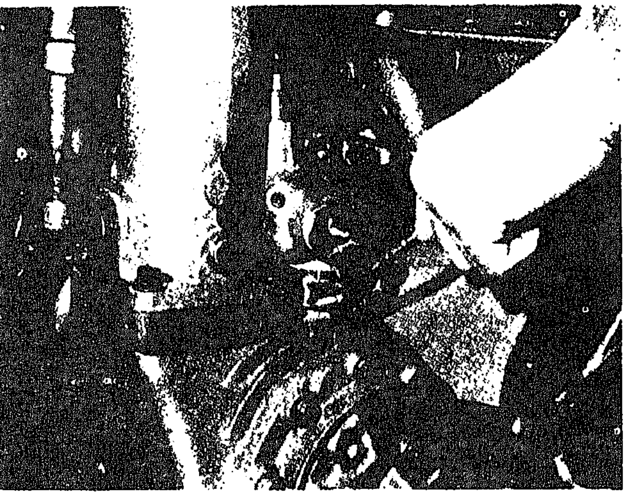


Fig. 14-1-63. Tightening manifold-to-supercharger clamp N20012

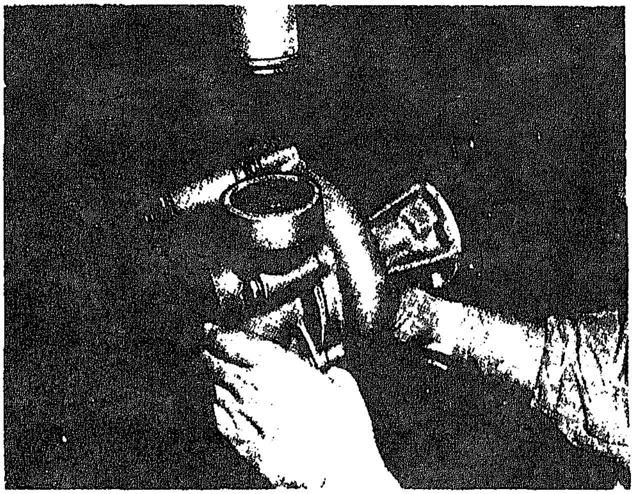


Fig. 14-1-64. Installing supercharger-driven water pump N20017

Water Pump

Supercharger-Driven

Assemble new "O" rings on oil cooler connection tube; secure tube to water pump with lockwasher and capscrew.

Assemble water pump and new gasket to rear of supercharger, Fig. 14-1-64.

Install mounting lockwashers and capscrews; tighten securely.

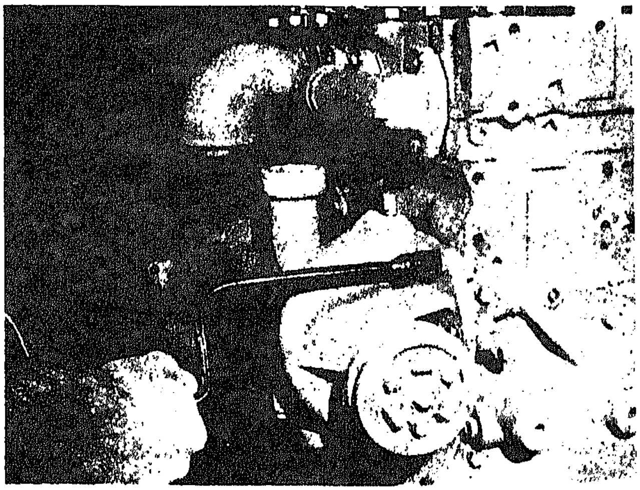


Fig. 14-1-65. Securing water pump to block N21489

Thermostat Housing And Connections

Using a new seal, install new or tested thermostat in thermostat housing.

Note: If thermostat with "V" notch is used, plug vent hole in housing.

2. Install thermostat with vent hole at top; failure to do so may result in air lock and incomplete coolant circulation.
3. Install new "O" rings on water by-pass connection; slip connection into water pump connection, Fig. 14-1-66.
4. Using new gasket, secure thermostat housing to cylinder head with lockwashers and capscrews, Fig. 14-1-67.
5. Position water connection over by-pass tube and against thermostat housing with new gasket; secure to thermostat housing with lockwashers and capscrews.
6. Install water outlet connection with new gasket to water by-pass connection; secure with lockwashers and capscrews.

7. Install air bleed line between by-pass connection and water pump body.

Oil Cooler

1. Install new "O" rings on oil cooler connection; insert connection into water pump connection.
2. Lift cooler assembly into position; slide cooler over cooler connection.
3. With new mounting gaskets in position, secure cooler to block with lockwashers and capscrews.
4. If used, install oil by-pass drain line from cooler to block.

Cranking Motor

Install cranking motor (and spacer, if used) in flywheel housing, Fig. 14-1-68; secure with lockwashers and capscrews.

Oil Gauge Tube And Bracket

Install bracket assembly and new gasket on oil pan, Fig. 14-1-69; secure with lockwashers and capscrews.

Corrosion Resistor

1. Secure mounting bracket to engine with lockwashers and capscrews.

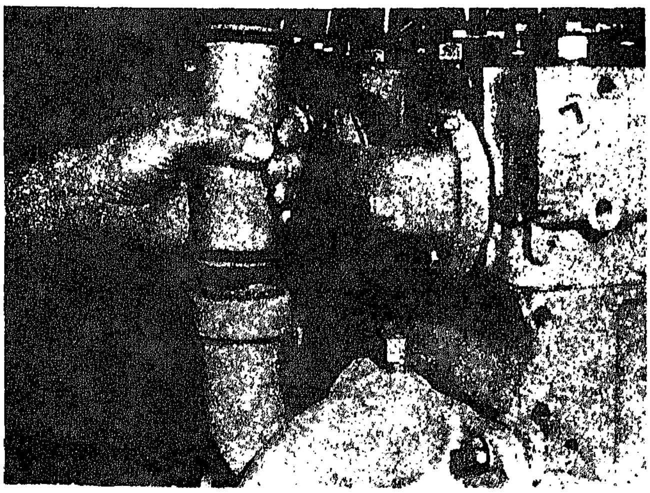


Fig. 14-1-66. Installing water by-pass connection N21490

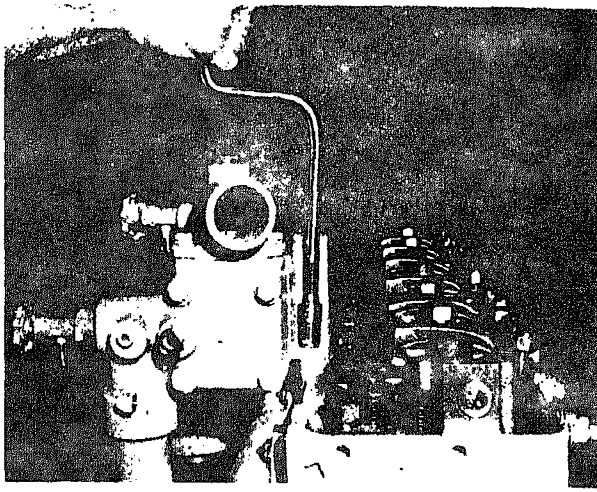


Fig. 14-1-67 Installing thermostat housing N21

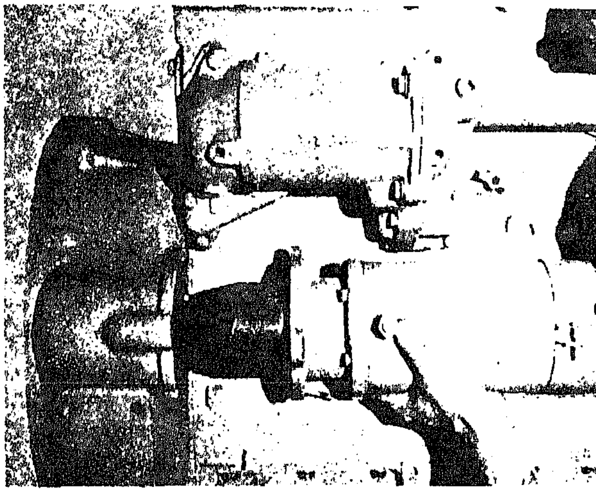


Fig. 14-1-68. Installing cranking motor N21

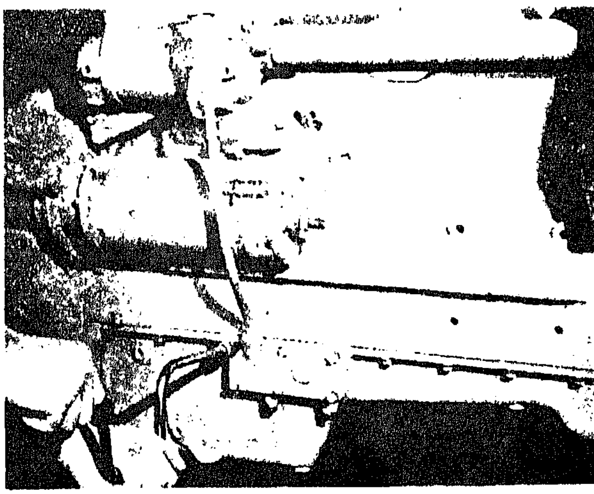


Fig. 14-1-69. Installing dipstick tube and bracket assembly N2

lount corrosion resistor to bracket with nuts, washers, ockwashers and capscrews.

lote: Corrosion resistor may be mounted on chassis, but iust be grounded to engine.

nstall corrosion resistor water lines.

uel Inlet And Drain Manifolds

nstall inlet and drain manifolds to fuel connections. When acing fuel pump side of engine, inlet connections are on ght side and drain connections are on left side of each jector.

o avoid cross-threading, start tube nuts by hand.

emoving Engine From Stand

sing suitable hoist, place Lifting Fixture over en- ine; screw lifting screws into cylinder head.

ake up enough slack in hoist chain to allow capscrews to e removed that are securing block to engine stand.

ift engine from stand, Fig. 14-1-70; set on engine supports.

emove lifting fixture from engine.

)il Transfer Connection

osition oil transfer connection and new gaskets to block; ecure with flatwashers, lockwashers and capscrews, Fig. 4-1-71.

ir Compressor

Cummins Gear-Driven

Jsing new gasket, position compressor and drive assembly nto gear cover; be sure timing marks on camshaft gear nd drive gear are indexed, Fig. 14-1-72.

iecure compressor and drive assembly to gear cover with ockwashers and capscrews.

nstall compressor water inlet and outlet tubes.

nstall size #4 oil inlet hose between rifle drilling at front of block and compressor oil inlet, unless bushing-type ac- essory drive bore is in gear cover.

lote: Use restrictor-type fittings on externally lubricated ompressor oil lines, Part No. 69099.

f used, install oil outlet line to air compressor support and ubricating oil filter head, after oil filter is installed.

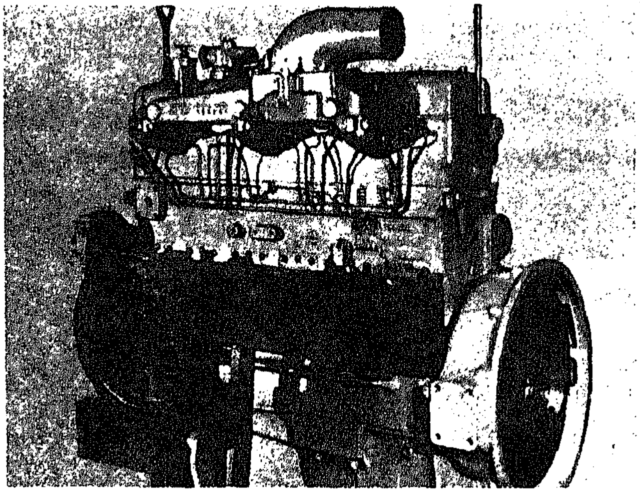


Fig. 14-1-70. Removing engine from engine stand N20010

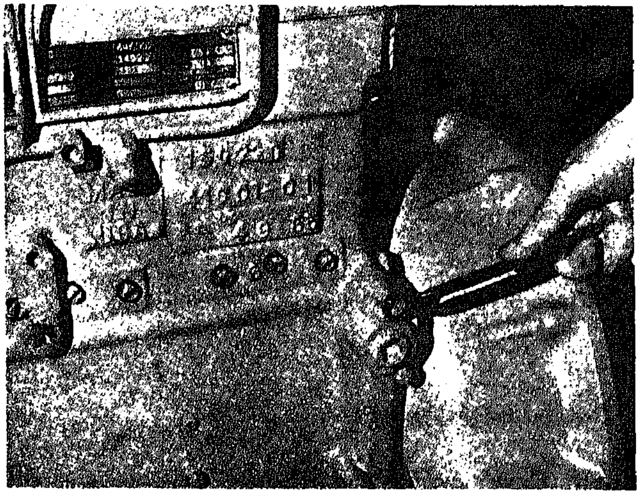


Fig. 14-1-71. Securing oil transfer connection to block N20037

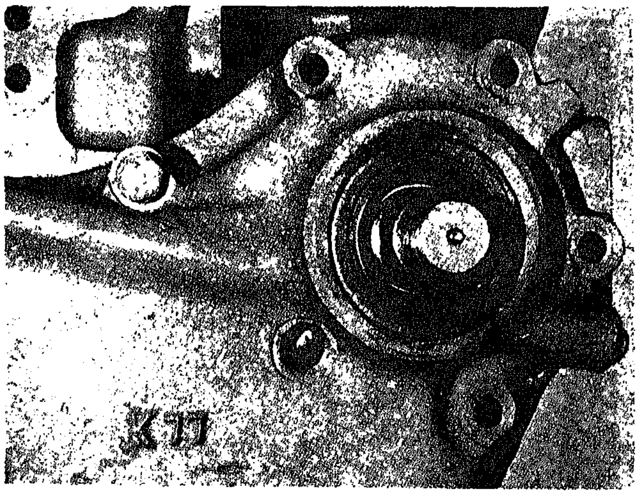


Fig. 14-1-72. Indexing timing marks on compressor gear and camshaft gear N21426

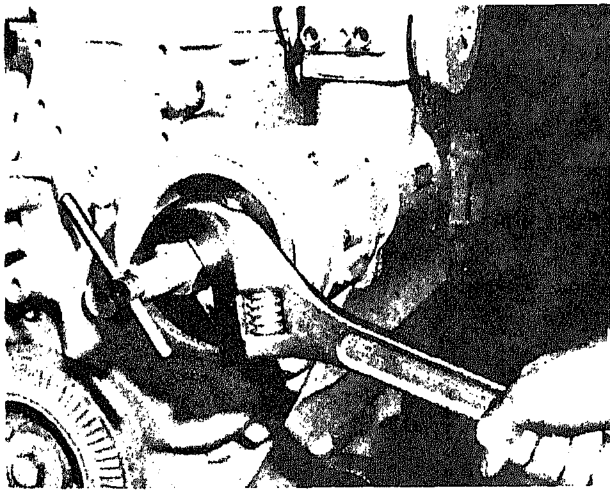


Fig. 14-1-73. Installing accessory drive pulley N21

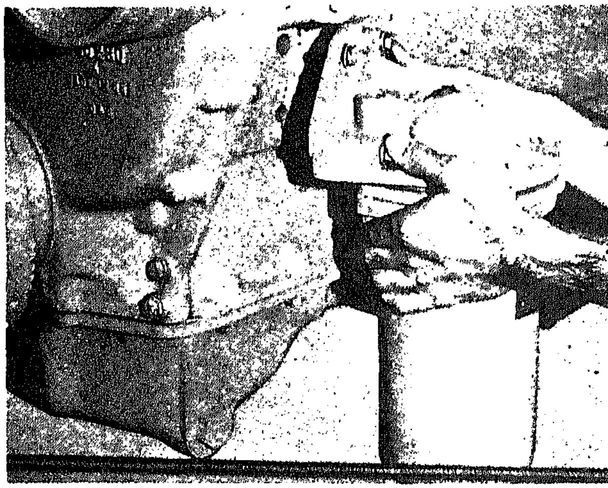


Fig. 14-1-74. Installing lubricating oil filter N21

Accessory Drive

1. Install accessory drive in gear cover oil seal and shaft bearing (or bushing); be sure to index timing marks on camshaft gear and drive gear.
2. Secure accessory drive to cover with lockwashers and capscrews.

Accessory Drive Pulley

1. Insert key in accessory drive shaft.
2. Slide pulley onto shaft until it binds.
3. Using Pulley Assembly Tool, press pulley onto drive shaft, Fig. 14-1-73.
4. Install flatwasher and locknut (or capscrew, if used).
5. Tighten locknut (or capscrew) to 90/100 ft. lb. [12.4470/ 13.8300 kg m].

Full-Flow Lubricating Oil Filter

Block-Mounted

Using new mounting gasket, position filter and head assembly on block, Fig. 14-1-74; secure with lockwashers and capscrews.

Remote-Mounted

If filter is mounted on engine, proceed as follows:

1. Secure mounting bracket to engine with lockwashers a capscrews.
2. Position oil pressure regulator and filter assembly bracket and secure with lockwashers and capscrews.
3. Install lubricating oil inlet and outlet lines.

Fuel Pump

mount pump and new gasket to compressor with buffer, Fig. 14-1-76, or to accessory drive flange with splined coupling.

Install lockwashers and capscrews; tighten mounting capscrews.

Install #10 fuel inlet hose to fuel pump.

Install fuel pump by-pass or fuel coolant line.

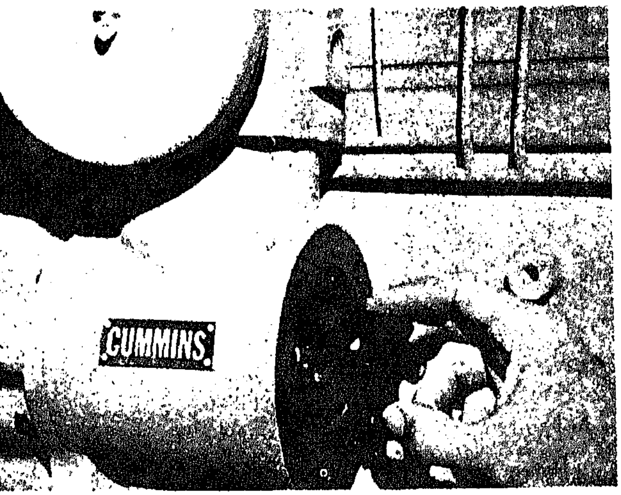


Fig. 14-1-76. Installing nylon buffer N2146

Fuel Filter

Replaceable Element Type

Position mounting bracket in desired location; secure with lockwashers and capscrews.

Check fittings in filter head for leaks. Fittings should be tightened to 30/40 ft. lbs. [4.1490/5.5320 kg m].

Install filter head to mounting bracket; secure with lockwashers and capscrews.

Install a new gasket in filter head and assemble case and element. Tighten center bolt to 20/25 ft. lbs. [2.7660/3.4575 kg m] with a torque wrench.

5. Connect fuel supply line between fuel filter and fuel pump.

Fan, Fan Hub And Bracket

1. Place fan hub and bracket assembly in position against front of block, Fig. 14-1-80. Install flatwashers, lockwashers and capscrews; screw capscrews in 2 or 3 turns.
2. Install all "V" belts; let generator/alternator belt hang loosely until generator/alternator is installed.
3. Tighten bracket mounting capscrews.
4. If fan hub is adjusted with adjusting screw, adjust belt tension (See Belt Tension, Page 14-1-29) by turning adjusting screw; then tighten shaft nut (behind bracket) to 400/450 ft. lbs. [55.3200/62.2350 kg m] with Fan Hub Nut Wrench.
5. If fan hub is adjusted with an eccentric shaft, turn shaft with Wrench until proper tension of belts is reached; using Wrench, tighten shaft locknut to 400/450 ft. lbs. [55.3200/62.2350 kg m].

Adjust Injectors And Valves

Injector Adjustment

1. Using ST-747 Barring Wrench on accessory drive pulley, Fig. 14-1-81, bar engine in direction of rotation to No. 1 top-center firing position. In this position, intake and exhaust valves for No. 1 cylinder are closed. If not, rotate engine one full turn.
2. Continue rotating crankshaft until valve set mark on accessory drive pulley aligns with timing marks on gear cover, Fig. 14-1-82 (1-6 VS on 6-cylinder engines). When these marks align, the engine is in position to adjust valves and injector plungers for No. 1 cylinder.
3. Check intake and exhaust valve position of cylinder to be adjusted. See that valves are closed and rocker levers free.
4. Check threads on adjusting screw and nut. See that they are clean, well oiled and free-turning.
5. Turn injector adjusting screw down until plunger contacts

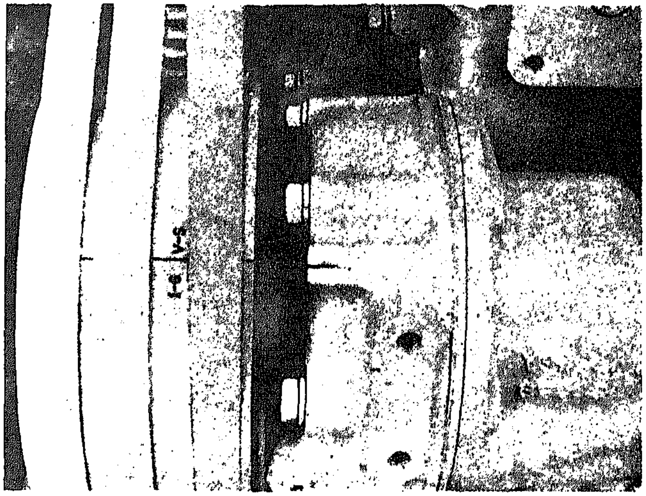
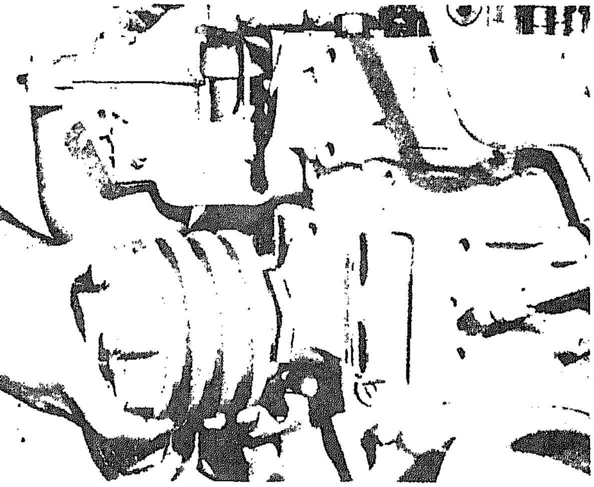
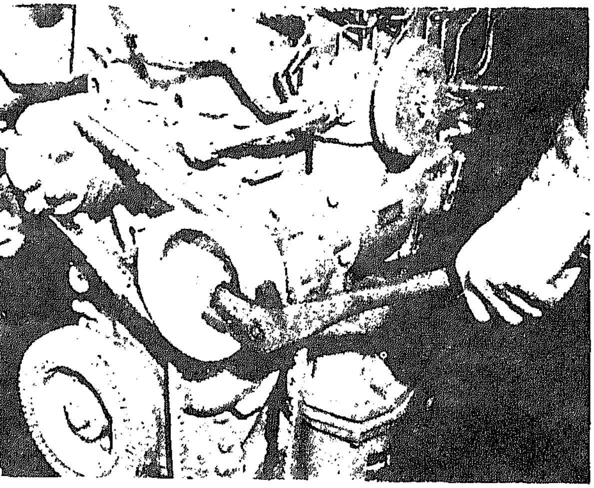


Fig. 14-1-82. Timing marks on accessory drive pulley N21459



g. 14-1-80. Installing fan hub and bracket assembly N21463



. 14-1-81. Barring engine N214100

cup. Turn adjusting screw an additional 15° to squeeze oil from cup.

6. Loosen adjusting screw one turn.
7. Tighten adjusting screw to 48 in. lbs. [.5520 kg m] (70°F.) [21.1°C.] setting. Use a torque wrench equipped with a screw driver adapter, graduated in inch-pound divisions, and having a maximum capacity of 150 in. lbs. [1.7250 kg m], Fig. 14-1-83.

   Setting at 70°F. [21.1°C.] is 48 in. lbs. [.5520 kg m].

   Setting at 140°F. [60°C.] is 60 in. lbs. [.6900 kg m].
8. Tighten locknut (with screw in place) with torque wrench and screwdriver to 70/80 ft. lbs. [9.6810/11.0740 kg m], Fig. 14-1-84.
9. Make final adjustment when engine is at operating temperature (140°F.) [60°C.].

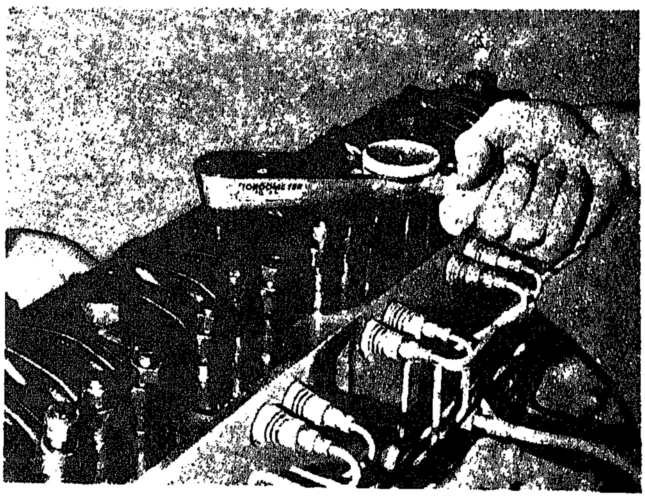


Fig. 14-1-83. Torquing injector lever adjusting screw N21460

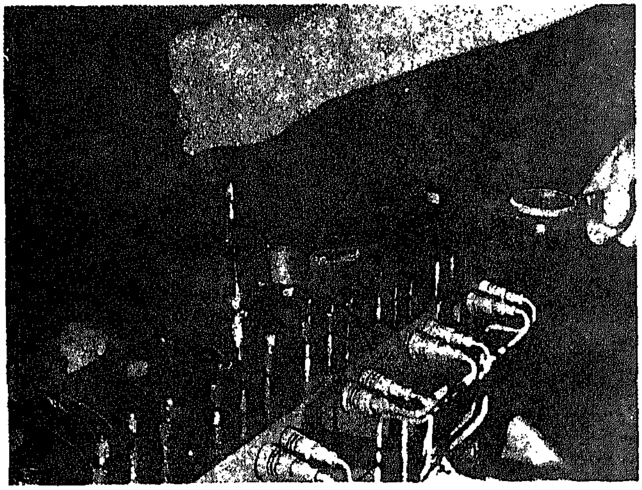


Fig. 14-1-84. Torquing injector lever locknut N214101

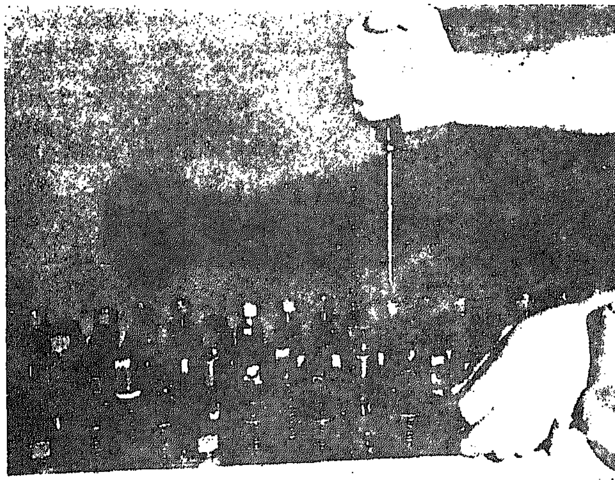


Fig. 14-1-85. Setting valve clearance N214

Valve Adjustment

The same crankshaft position used in setting injectors is used for setting intake and exhaust valves. Set valves after injectors are adjusted.

1. Loosen locknut and adjusting screw. Insert a feeler gauge between rocker lever and top of valve stem or crosshead and turn screw down until lever just touches feeler gauge, Fig. 14-1-85 and Table 14-1-5.

Table 14-1-5: Valve Settings

Valve	70°F. [21.1°C.] In.	[mm]	90°F. [32.2°C.] In.	[mm]
Intake	0.017	[0.4318]	0.015	[0.3810]
Exhaust	0.027	[0.6858]	0.025	[0.6350]

2. Lock adjusting screw in position with locknut. Recheck valve clearance after tightening locknut.
3. Continue turning crankshaft in direction of rotation, performing adjustments until all valves are adjusted correctly.
4. Make final adjustments when engine is at operating temperature, 140° F. [60° C.]. See "ENGINE RUN-IN", Section 14-2.
5. Continue adjustments on each cylinder (in firing order) until all cylinders are adjusted. This will require two complete revolutions of the crankshaft

Engine Firing Order

6 cylinder — right-hand rotation — 1-5-3-6-2-4
6 cylinder — left-hand rotation — 1-4-2-6-3-5

Adjustment With Special Tool

Injectors

Use Adjustment Tool with standard ½ in. [12.70 mm] drive socket and torque wrench.

1. Perform procedures outlined in Steps 1 through 6 und "Injector Adjustment".
2. Place tool over rocker lever locknut and adjusting sc Place torque wrench calibrated in foot-pounds in to arm of tool and loosen locknut.
3. Loosen adjusting screw using torque wrench calibrated inch-pounds in screwdriver handle adapter socket.
4. Tighten adjusting screw to 48 in. lbs. [.5520 kg m] (70°F [21.1°C].
5. Hold adjusting screw firmly with screwdriver handle ST-669; tighten ⅝ in. [15.8750 mm] thread locknut to 60/ ft. lb. [8.2980/9.6810 kg m], ½ in. [12.7000 mm] thread loc nut 7/16 in. [11.1125 mm] thick to 60/70 ft. lbs. [8.2980/9.68 kg m], and ½ in. [12.7000 mm] thread locknut 5/16 in. [7.93 mm] thick to 30/35 ft. lbs. [4.1490/4.8405 kg m]. Make fin adjusting screw adjustments when engine is at operatin temperature (140°F.) [60°C.].

Valves

1. Place tool over valve adjusting screw and lockn Loosen locknut with torque wrench in torque arm of too
2. Loosen adjusting screw with screw driver handle of too
3. Place feeler gauge between rocker lever and crosshead valve stem. See "Valve Adjustment" for proper valve cle ance. Tighten adjusting screw until proper valve clearan is obtained.

Hold adjusting screw firmly with screwdriver handle of tool '; tighten 9/16 in. [14.2875 mm] thread locknut to 60/70 ft. lbs. [8.2980/9.6810 kg m] 1/2 in. [12.7000 mm] thread locknut 7/16 in. [11.1125 mm] thick to 60/70 ft. lbs. [8.2980/9.6810 kg m] and 1/2 in. [12.7000 mm] thread locknut 5/16 in. [7.9375 mm] thick to 30/35 ft. lbs. [4.1490/4.8405 kg m], Fig. 14-1-86.

Note: Lower torque setting is necessary to compensate for torque arm length on tool.

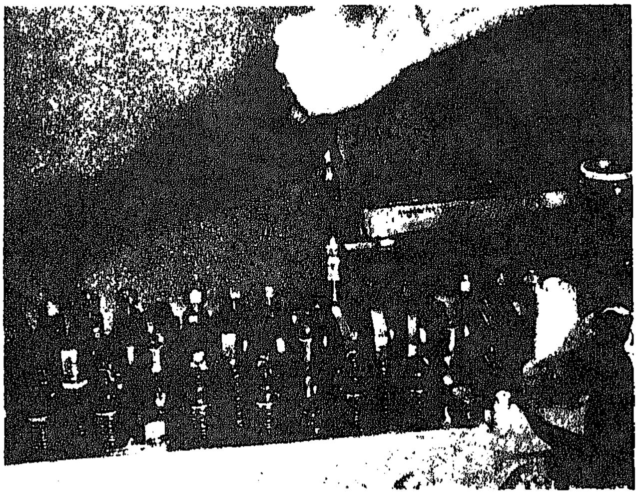


Fig. 14-1-86. Torquing valve lever locknut N214102

Rocker Lever Cover

Assemble new gasket, washers and capscrews to rocker lever cover.

Note: Some rocker lever covers have a gasket-retaining channel. Use only gasket Part No. 128428 with this style rocker lever cover.

Mount cover on engine, Fig. 14-1-87; tighten hold-down capscrews.

On supercharged engines, install vapor suction line connecting cover to supercharger air intake.

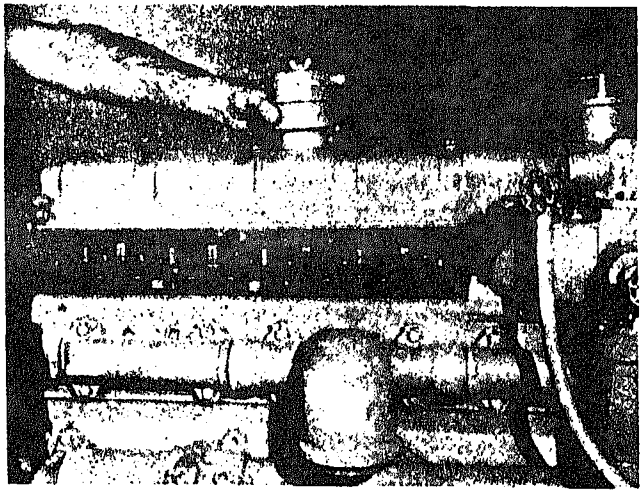


Fig. 14-1-87. Installing cylinder head cover N214103

Crankcase Breather

Install crankcase breather on cylinder head cover.

Install vent tube, if used.

Note: Use correct breather and rear oil seal combination. See "Crankcase Breathers", Group 3.

Air Intake Manifold

Assemble copper washers, capscrews and new gaskets on intake manifold.

Position manifold over ports in cylinder head, Fig. 14-1-88; secure capscrews.

Note: At this time, perform all necessary installing and connecting of tubing, inlet connections, etc., that must be done in conjunction with intake manifold.

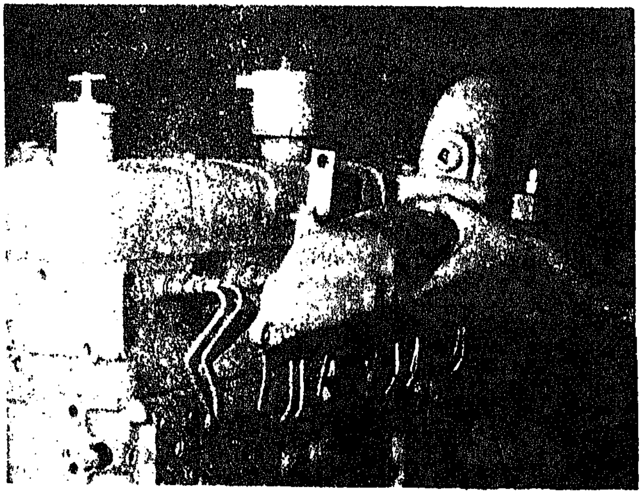


Fig. 14-1-88. Installing intake manifold N20089

Generator Or Alternator

Secure generator bracket(s) to engine with flatwashers, lockwashers and capscrews.

Install generator to bracket; secure with lockwashers and capscrews.

Install adjusting bar on generator and bracket. Install and adjust belt.

Engine Testing—Unit 1402

Engine break-in and testing are accomplished simultaneously. Break-in on a new or rebuilt engine is necessary because it provides an operating period during which moving parts acquire their final finish and mating surfaces reach a full seat. Engine testing helps detect possible assembly errors, need for adjustments as engine "breaks in", and establishes a period for final adjustments for best engine performance.

An engine dynamometer provides the simplest and most accurate tool for testing and break-in. Follow the instructions listed below in sequence for prestarting checks, dynamometer mounting, starting, testing, adjustments and break-in.

Priming The Fuel System

Priming of the fuel system is not necessary except as an aid to faster pickup of fuel, especially where the fuel tank is located away from the engine.

1. If fuel pump has a return line to the fuel tank, a few drops of clean lubricating oil in the gear pump will aid in fuel pickup.
2. If the fuel pump return opening, next to tachometer drive, is plugged, remove plug and fill fuel pump housing with clean No. 2 diesel fuel.
3. Fill fuel filter with clean No. 2 diesel fuel.

Priming Lubricating System

1. Fill crankcase to "L" (low) mark on bayonet gauge with lubricating oil. See **lubrication order.**
2. Remove pipe plug from priming point.

a. When engine equipped with "bag-type" full-flow lubricating oil filter is used, priming point is on side of block, Fig. 14-2-1.

b. When engine with "paper element" full-flow lubricating oil filter is used, priming point is as indicated in Fig. 14-2-2.

c. Engines with remote-mounted full-flow filters should be primed at inlet side of filter to prevent damage to filter element.

Caution: Priming the paper element filter at the wrong point will rupture the paper filtering media.

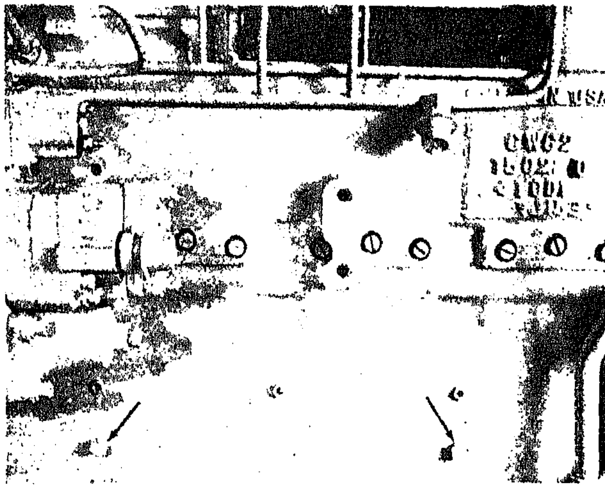


Fig. 14-2-1. Lubricating system priming point with bag-type filter N21

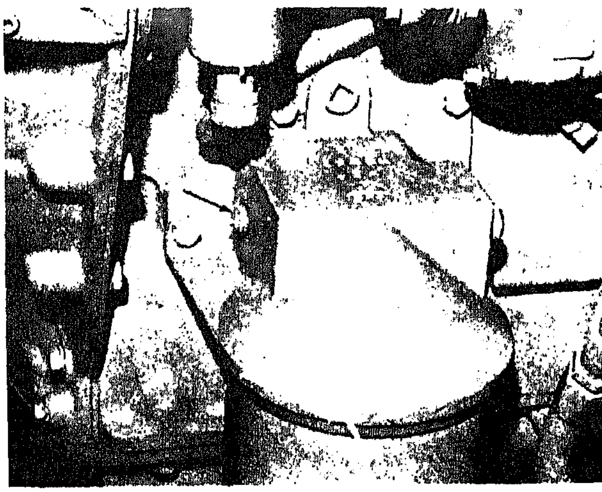


Fig. 14-2-2. Lubricating system priming point with paper element filter N214

3. Connect a hand or motor-driven priming pump line fr source of clean lubricating oil to engine pri ing point.
4. Prime until a 30 psi [2.1090 kg/sq cm] minimum pressure reached.
5. Crank engine for a minimum of 15 seconds with exter oil pressure at a minimum of 15 psi [1.0545 kg/sq cm].
6. Allow engine to fire and operate from 5 to 10 secon

hen shut down engine.

Remove external oil supply and replace plug, as required.

Check oil level on dipstick; bring level to "H" mark.

Caution: After engine has run a few minutes, it will be necessary to add lubricating oil to compensate for that taken up by the filter and oil cooler.

Lubricating Cranking Motor And Generator

Use clean lubricating oil to lubricate cranking motor bearings: avoid excessive oiling.

Use lubricating oil to lubricate generator bearings. Avoid excessive oiling which would damage wire insulation.

Injector And Valve Adjustments

Injector plungers and valves should be adjusted before starting the engine; refer to Group 14-1.

Engine Dynamometer

Check dynamometer capacity. Make sure capacity is sufficient to allow testing at 96% to 100% maximum engine horsepower. If capacity is insufficient, testing procedures must be modified to prevent damage to dynamometer.

Installation of Engine

Using proper lifting device, place engine on dynamometer test stand.

Position engine on the front engine support and preselected risers for the rear engine supports; secure engine mounting pads to engine support risers with bolts, lockwashers and nuts. Remove lifting device.

Position dynamometer driveshaft flange to engine flywheel. Use proper flywheel adapter flange to match flywheel capscrew holes.

4. Check for proper alignment.

a. If direct or flexible-drive coupled, place a dial gauge holding fixture on face of flywheel housing and dial gauge on adapter flange hub; bar engine over to obtain reading. Relocate flange hub on flywheel as needed and retighten capscrews. Flywheel adapter flange must be concentric to flywheel and flywheel housing within 0.005 in. [0.1270 mm] total runout. When using a direct-coupled dynamometer a reading must be taken from face of flywheel housing to outer edge of dynamometer drive flange. It must not exceed 0.005 in. [0.1270 mm] total runout when barring dynamometer over one complete revolution.

b. If universal-drive coupled, flywheel and dynamometer drive flanges must be concentric within 0.005 in. [0.1270 mm] runout; reading to be taken as above. Install engine so centerline of engine crankshaft and centerline of dynamometer drive shaft are, by design, out of plane either horizontally or vertically from ¼ in. [6.3500 mm] minimum to ½ in. [12.7000 mm] maximum. True alignment will cause universal bearing failure. Secure flywheel to drive flange with lockwashers and capscrews.

5. Connect water supply and return hose to the water cooling arrangement.
6. Attach .Flow Tank fuel line to the engine fuel drain connection.
7. Attach fuel pump return line, if used.
8. Attach fuel supply line to fuel pump suction connection.
9. Not applicable.
10. Connect electrical wiring to cranking motor if motor is to be used for starting. If another means of starting is to be used, make necessary connections.

11. Connect throttle linkage and all instruments which are included on the control panel of the particular dynamometer being used.

12. Connect exhaust piping to engine exhaust manifold.

13. Connect air intake piping to air intake manifold or air inlet connection. Use a standard air cleaner approved for engine model being tested.

14. Connect a full-flow lubricating oil filter to remove any entrapped dirt or grit.

15. On naturally aspirated engines, remove rocker housing covers and plug vent holes in cylinder heads before making blow-by check. Failure to do so will give false readings.

Caution: After testing, remove pipe plugs from cylinder heads of naturally aspirated engines.

16. Install Blow-By Checking Tool to crankcase breather opening or special rocker cover with adapter. See Fig. 14-2-4.

17. Install water manometer to and fill manometer with

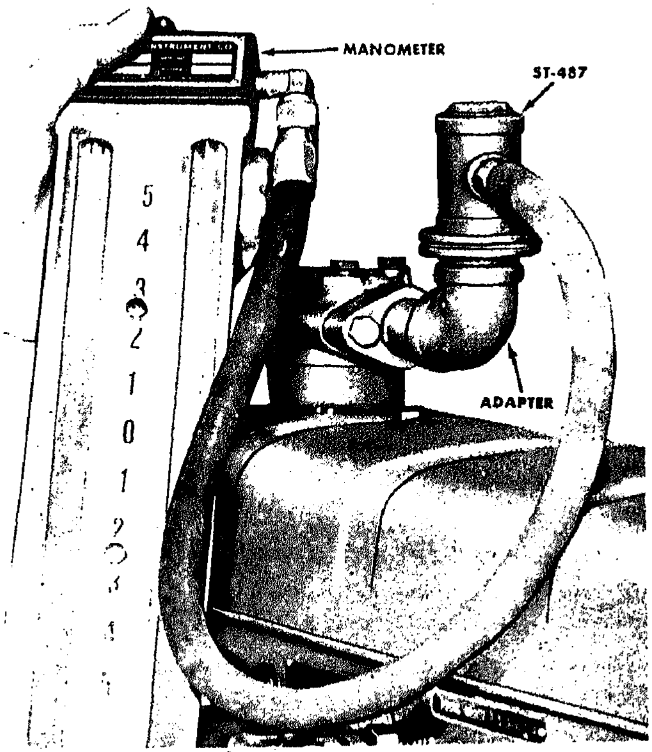


Fig. 14-2-4. Checking blow-by with ST-487 N21472

water to "O" mark at middle of scale.

18. Close all openings that would allow blow-by pressure to escape. All connections must be air tight.

19. Start engine. See "Starting Procedure".

20. Open coolant supply valves to heat exchanger or connection. Introduce water to the absorption uni manufacturer's instructions.

21. Check all tubing, hose, lines, fittings and plugs for Correct as necessary.

22. For engine run-in, see "Test Procedure".

23. After test remove plugs from naturally aspirated e vent holes installed in Step 15.

Starting Procedure

Normal Without Cold-Starting Aid

1. Set throttle for idle speed.

2. Open manual fuel shut-down valve, if used. Electric shut-down valves operate automatically, or if not energ open by using manual over-ride knob.

   Note: A manual over-ride knob provided on the for end of the electric shut-down valve allows the valve t opened in case of electric power failure or if power is available during testing. To use, open by turning clockwise.

3. Start engine. Press starter button (1, Fig. 14-2-5), or switch key to "start" position.

   Caution: Do not crank engine continuously for more 30 seconds. If engine does not fire within 30 seconds, two to five minutes before repeating to avoid cra motor damage.

On engines equipped with an oil pressure switch, fuel by-pass switch must be in "START" position be- use of priming pump.

: On engines with oil pressure safety switch, hold fuel ass switch in "START" position until engine oil pres- reaches 7 to 10 psi [0.4921 to 0.7030 kg/sq cm]; then to "RUN" position.

Other Cold-Starting Aids

1. Ether-Compound Metering Equipment consists of a metering chamber for ether compound capsules and controls to release the starting compound during cranking.

   The starting fluid is released between air cleaner and supercharger on supercharged engines. On nonsupercharged engines, it enters the air intake manifold. To start engine so equipped:

a. Close shut-off cock. If properly installed, the spring will hold it closed.

b. Remove cap and insert capsule of starting fluid.

c. Push cap down sharply to puncture capsule: tighten one-fourth turn.

d. Wait 30 seconds before engaging starter.

e. Engage starter and, while engine is being cranked, open the shut-off valve.

   Caution: Do not open valve before cranking engine or all fluid will drain into the intake air before cranking, and there will be one excessively heavy charge instead of the metered amounts which starting requires.

f. After engine has started and all fluid has drained out of chamber, close valve to keep dusty air out of engine.

g. Remove and discard empty capsule; reassemble empty primer.

2. If the engine is not equipped with a preheater arrangement or ether compound metering equipment, the following method can be used to start the engine:

a. Two men will be required for this operation; one cranks the engine while the other applies ether to the air intake.

   Caution: Never handle ether near an open flame. Never use with preheater or flame thrower equipment. Do not breathe fumes.

Break-In Run

Initial Starting

1. Start engine and idle at approximately 800 rpm no load for five to ten minutes.
2. Check oil pressure and water circulation; look for leaks.

At Each Phase

1. Apply dynamometer load to develop horsepower (±10%) at speed (±5%) shown in Table 14-2-2 "Dynamometer Charts".
2. Check crankcase pressure (blow-by) Refer to Page 14-2-9. If pressure continues to drop, reduce run-in time by half; otherwise, run engine for time period shown on dynamometer chart.

At Phase 1 Only

1. Run engine until temperature reaches 160° F. [71° C.].
2. Add lubricating oil to bring level up to "H" mark on bayonet gauge.

At Phase 2 Only

1. Reset valves and injectors. See Section 14-1.
2. Set engine idle, governed speed and fuel rate.

At Phase 3

If blow-by rises, reduce load to preceding phase and run for 30 minutes; then return to original phase specifications.

At Phase 4

1. Run at speed and horsepower indicated.
2. Check thoroughly for leaks and tighten all exposed capscrews.

Power Check

1. Run engine at rated speed for 5 minutes. It should deve 96% of rated horsepower at standard fuel rate. Ch crankcase pressure (blow-by).
2. If crankcase pressure exceeds value shown, reduce eng speed and load to preceding phase; run engine 30 to minutes.
3. Repeat procedure described above until engine devel 96% rated horsepower at standard fuel rate within perm sible crankcase pressure limit.

Checks During Run-In Test

During the period of engine run-in, the following chec should be made frequently:

Lubricating Oil

1. Lubricating oil pressure should remain at or near a co stant figure at constant engine speed and load (see Ta 14-2-3) after normal operating temperature has be reached. Abnormal high pressures may indicate block lubricating oil lines. Abnormal low pressures indicate insufficient supply of lubricating oil from the pump or creased oil clearances which may be due to bear failure.

Table 14-2-3: Normal Lubricating Oil Pressure

Idle PSI [kg/sq cm]	Rated Speed PSI [kg/sq cm]
10/30 [0.7030/2.1090]	40/75 [2.8120/5.2725]

Note: Individual engines may vary from above pressure

2. Temperature of lubricating oil should be approxima 225° F. [107° C.] or less during engine operation. If temperature rises sharply above 225° F. [107° C.] s down engine and correct as necessary.
3. The new element or bags in the lubricating oil filter absorb lubricating oil; therefore, engine must be shut do after five or ten minutes operation and additional lubri ing oil added to crankcase to bring oil level to "H" m on bayonet oil gauge. Check oil level every two hours d ing run-in test.

ngine Coolant

fter engine is started, add coolant as necessary to com-letely fill cooling system and replace entrapped air.

oolant should not exceed 200° F. [93° C.] or drop below 60° F. [71° C.] during engine operation.

o not turn engine off immediately after a load run. Heat tored in the iron masses will boil coolant in the jackets f air and coolant circulation is immediately stopped while ngine is hot. Allow engine to idle for a few minutes be-ore shutting down.

uel Pressures

isted below are three methods of checking fuel manifold ressure. The engine must be at operating temperature nd fuel system purged of all air.

he preferred method of checking engine manifold pres-ure is to load engine on an engine or chassis dynamom-ter as follows.

heck governor cut-off.

t full throttle increase load until engine is pulled down to ated speed (accurate tachometer must be used). Read fuel nanifold pressure. If engine fuel manifold pressure is be-ow minimum or above maximum specifications

make the following adjustments.

o Raise Pressure:

crew out maximum throttle rear stop screw and utilize hrottle restriction that may be present.

Caution: Do not turn the screw out beyond maximum throttle opening point; otherwise a dead throttle travel may occur.

Remove throttle shaft and add fuel adjusting shims as re-quired.

To Decrease Pressure:

Caution: Under no circumstances should engine manifold pressure be set above maximum specifications. Doing so will void engine warranty.

Remove throttle shaft and remove shims as required.

t should not be necessary to adjust fuel manifold pressure on a newly calibrated pump more than 5 psi [.3515 kg/sq cm]. If adjustments greater than these are required, fuel pump test, injector test stand or engine problems may exist.

The next best method of checking maximum engine fuel manifold pressure (in automotive applications) is to note maximum pressure while accelerating at full throttle when going up through the transmission ratios. With proper gauge snubbing, this method can be relatively accurate, es-pecially if a heavy load is being pulled and engine accel-eration in higher gears is slow.

3. The least preferred method of checking maximum engine fuel manifold pressure is the so-called "snap" pressure check method.

a. The "snap" method is not as reliable as method 1 and 2 because the pressure reading is of very short duration.

   Gauge inertia, the degree of throttle manipulation, also re-duces the reliability of "snap" pressure readings.

b. To take "snap" pressure readings, attach the ST-435 pres-sure gauge at the shut-down valve in the usual manner, Fig. 14-2-6.

c. Disconnect throttle control linkage at throttle lever. Move lever clockwise against stop.

d. Start engine and run engine speed up to 200 to 300 rpm above idle by opening throttle slightly; then snap throttle to fully open position and permit engine to accelerate to maximum speed while observing pressure gauge. Note mo-mentary maximum pressure. Take this reading several times.

   Due to its poor reliability and inherent inaccuracy this check should not be used to gauge fuel pump test stand calibration accuracy.

Fuel Lines

Check all fuel lines and fuel connections; see that they are tight and not leaking.

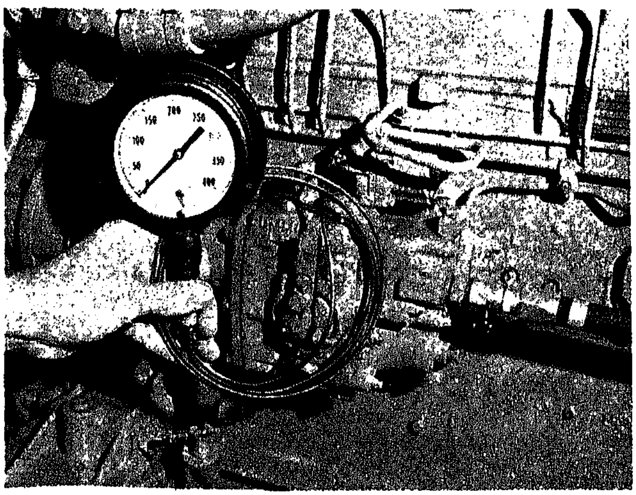


Fig. 14-2-6. Checking fuel manifold pressure N21473

Lubricating Oil Lines

1. Check all lubricating oil lines and connections; see that lines on pressure side of lubricating oil pump are not leaking.
2. Leaks are harder to detect in lubricating oil suction lines than on pressure side of pump. These can generally be detected by testing with oil from an oil can. If suction lines leak, it may cause foaming of oil in the crankcase, and, eventually, bearing failure.

Overspeed Stop

1. Overspeed stops, when used, are set to trip and shut-off fuel supply when engine exceeds maximum rated speed by approximately 15%. Under certain conditions, overspeed stops may permit enough fuel to pass to operate engine at idling speed.
2. After determining and correcting cause of overspeed stop trip, reset in running position. See page 14-2-12 for adjustments.

Engine Fuel Rate

Engine fuel rate (fuel consumption) in lbs. per hr. is measured by using Flow Tank, or a suitable means of weighing the fuel.

1. The fuel rate specified in fuel pump calibration specifications is at full throttle and rated speed. Reference PT Pump Calibration Group 501.
2. An engine dynamometer, chassis dynamometer or other controlled means of loading engine must be used. Accurate fuel manifold pressure and speed readings must also be taken.
3. To check engine fuel rate, load engine at full throttle until engine speed is pulled down to, and kept at, rated speed (check governor cut-off speed as described above while loading engine). Note fuel manifold pressure at rated speed. Hold engine speed and load, stable at rated speed long enough for the flow meter float to stabilize. Take the fuel rate reading.
4. If weight scales are used, hold load and fuel manifold pressure stable with full throttle at rated speed. With stop watch or other suitable timer, check number of pounds of fuel to be used in a five-minute period of time (this can then be multiplied by twelve, giving the lbs. per hr. fuel rate). Run several checks and average the readings, if they vary several lbs. Note full power smoke level for use in analyzing engine performance.

Blow-By Readings

1. Manometer readings must be taken frequently during run-in test so the test mechanic will note any blow-by increa at a given speed and load. If there is any indication blow-by increase, engine speed must be reduced for a f minutes and then brought back to the original test rpm
2. During each power check, keep a constant check on t manometer; if pressure rises, more run-in is required. Re resentative pressure limits for engine running at govern speed and pulling 96% to 100% of rated horsepower a given in Table 14-2-2.
3. If crankcase pressure, or blow-by, is greater than valu listed in Table 14-2-2 at end of testing period, engi should be rejected.
4. Conditions under which engines exceeding maximum blo by limits (specified in table) during break-in may be a cepted are:

Operate 30 minutes extra at 96-100% rated load and RP If there is no rapid change in excess of 2 in. [50.8 mm] water and reading does not exceed 125% of representati pressure, blow-by is acceptable.

Load Applications (Installed Engine)

After run-in procedure described above, it should be e plained to the operator that during long hard pulls in e cess of ten minutes of continuous operation, it is best drop to a lower gear (or reduce load) to prevent maxim horsepower demand during the first 50 hours of operati This gives new parts a chance to "wear in" without und stress and strain.

Chassis Dynamometer Tests

If the engine is installed in equipment, it may be tested a chassis dynamometer as follows:

1. Read instruction manual before attempting to operate d namometer.
2. If ratchet pawls are used, locate in extreme safety po tion before running vehicle on dynamometer.
3. Check coolant and oil supply in vehicle. If low, vehi may overheat on test.
4. Lubricate dynamometer as recommended by manufactur
5. Check instruments.
6. Introduce cooling water to dynamometer as recommend

/ manufacturer. Be sure main water supply valve is open etween water source and dynamometer control valves.

o not allow absorption unit to operate at temperatures bove maximum specified by dynamometer manufacturer.

perate vehicle in highest gear.

olls and flywheel must be stopped before engaging.

o not exceed recommended speed of units.

ake precautions to keep water out of bearings, torque ridge, generator, etc.

aintenance of Dynamometer

ollow manufacturer's maintenance instructions to service ynamometer.

alibrating Instruments

eep beam or spring scales properly calibrated.

ollow manufacturer's recommendation when recalibrating necessary.

instruments need adjustment, follow manufacturer's in- ructions.

-Chassis Run-in

-chassis repaired engines should receive run-in equiva- nt to that on an engine dynamometer. Follow procedure iven below after an in-chassis repair or rebuild.

tart engine. Idle at 800 to 1000 rpm, no-load, for 5 to 10 inutes.

heck oil pressure and water circulation. Correct any aks.

possible, place unit on chassis dynamometer and op- rate at 30% rated load and 75% rated speed. Limit run-in one hour.

un-in (No Dynamometer)

an engine or chassis dynamometer is not available, op- rate engine at one-fourth to one-half throttle for the first to 3 hours.

uring next 45 to 50 hours operate at 50% to 65% throttle. o not operate engine at full-load and speed in excess of vo minutes continuously at any time. After short runs (2

a. Operate at one-half to three-quarters throttle. Do not operate at maximum horsepower for more than five minutes at a time.

b. Do not idle the engine for long periods as this will cause cylinder walls to glaze before the piston rings seat properly and result in excessive lubricating oil consumption.

c. Watch the instruments closely. Decrease engine rpm if oil temperature reaches 250° F. [121° C.] or if coolant temperature exceeds 190° F. [88° C.].

d. Operate with a power requirement low enough to allow acceleration to governed speed under any condition.

Engine Storage—Unit 1403

On any engine not in service, whether installed in equipment or waiting to be installed, the unpainted machined surfaces are subject to rust and corrosion. Often an engine is not prepared for storage with rust-proofing measures taken, because it is not thought that the engine will be out of service for a long period. However, any engine temporarily stored, whether one taken out of service or a new engine not yet placed in service, is subject to rust damage.

The rate of corrosion varies with climatic conditions. An engine stored in a climate with a high amount of moisture in the air will corrode more rapidly than an engine stored in a dry climate. Variance in climatic conditions makes it impossible to state the length of time an engine can be stored without rust and corrosion damage.

Temporary Storage

If an engine remains out of service for three or four weeks (maximum six months) and its use is not immediately forthcoming, special precautions should be taken to prevent rust. Only the operations listed below are required to minimize or prevent damage resulting from lack of attention to temporarily stored engines.

1. Using diesel fuel, the engine must be started and the speed gradually increased to 1,200 rpm or a fast idle, with no load, and operated until the engine is thoroughly warm.
2. Engine fuel intake line must be disconnected at the most easily accessible point nearest the fuel tank. Connect a line from a portable container filled with diesel fuel U. S. Specification VV-F-800 Grade DF-2 to the fuel inlet.
3. A line should be provided and connected to the injector fuel return quick-disconnect coupling to permit draining into a recovery container. Recovered fuel oil mixture should not be reused for preserving other engines.
4. Start engine and accelerate to 3/4 speed; at the same time switch fuel supply to a portable container filled with preservative oil, U. S. Military Specification Mil-1-644 type P-9. Operate engine until entire fuel system and internal operating surfaces are coated with preservative oil (this takes from 5 to 10 minutes). Stop engine and reconnect fuel lines.
5. The sumps, fuel filters and fuel tank, if so equipped, must be drained and drain plug reinstalled.
6. Remove engine intake manifold.
7. Spray SAE 10 lubricating oil into exhaust manifold and each intake port while cranking engine over slowly with intermittent turning of switch key or by tapping starter button.

   Caution: Disconnect line from fuel pump to fuel manifold and crank slowly to prevent engine from starting.
8. Install intake manifold and cover opening with tape to prevent entrance of dirt.
9. Remove rocker housing covers and spray rocker arms, valve stems, springs, guides and push tubes with SAE 10 lubricating oil. Replace covers.
10. Cover all engine openings, including coolant inlets to cylinder head, cylinder block, oil breather and crankcase.
11. Loosen V-belt tension.
12. Drain coolant from cooling system unless it is permanent-type antifreeze with rust inhibitor added.
13. Store engine in a place protected from weather where air is dry and temperature uniform.

Permanent Storage

1. When an engine is to be stored for a long period (more than six months), the lubricating and fuel systems should be treated with rust-proofing preservative oil. The preservative oil should conform to U. S. Military Specification Mil-L-21260, type P-10, Grade 2, SAE 30.
2. Loosen V-belt tension.
3. The cooling system should be protected from rust and corrosion with a rust preventive compound conforming to U. S. Military Specification Mil-C-4339B.
4. To protect the engine exterior and unpainted surfaces, use a rust preventive compound conforming to Type P-2, grade 1 or 2, as described in U. S. Military Specification Mil-C-16173C.
5. Although the preservative materials may be added to and used for the same purpose repeatedly, they must be kept clean. When repeatedly used, the accumulated dregs should be removed after being allowed to settle.

Application of Engine Preservatives

1. Drain lubricating oil from all filters and crankcase. Drai

all mounted accessories such as air compressor, governor, oil cooler, etc., that are supplied with oil from the engine crankcase. Replace all plugs.

Fill crankcase to full mark on bayonet gauge or dipstick with preservative oil, U. S. Military Specification Mil-L-21260, type P-10, Grade 2 SAE 30.

Remove rocker housing cover and spray preservative oil over-rocker levers, valve stems, springs, guides, crossheads and push tubes. Replace cover.

Using diesel fuel, the engine should be started and the speed gradually increased to 1200 rpm or a fast-idle, with no load, and operated until the engine is thoroughly warm.

Engine fuel intake line should be disconnected at the most easily accessible point nearest the fuel tank. A line from a portable container filled with diesel fuel U. S. Specification VV-F-800, Grade DF-2 must be connected to line leading to engine.

A line must be provided and connected to the injector fuel return quick-disconnect coupling to permit draining into a recovery container. Recovered fuel oil mixture should not be reused for preserving other engines.

Start engine and accelerate to 3/4 speed; at the same time switch fuel supply to a portable container filled with preservative oil U. S. Military Specification Mil-L-644 type P-9. Operate engine until entire fuel system and internal operating surfaces are coated with preservative oil (this takes from 5 to 10 minutes). Stop engine and reconnect fuel lines.

The fuel tank, if so equipped, must be drained and drain plug reinstalled.

Disconnect turbocharger or supercharger to keep preservative oil from entering them.

Operate engine for five minutes at idling speed to insure thorough distribution of preservative oil. Stop engine and drain all sumps, filters and crankcase. Replace all plugs after draining.

Disconnect supply lines from portable container and reconnect fuel line to fuel pump.

Remove intake and exhaust manifolds.

Spray all intake and exhaust ports, including air compressor intake port, with preservative oil.

Replace intake and exhaust manifolds.

If air starter is used, remove exhaust plate from top of starting motor and spray with preservative oil. Replace exhaust plate.

Inspect coolant in cooling system. If coolant is contaminated, drain and flush with U. S. Military Specification Mil-C-10597; if required, fill with rust preventive compound U. S. Military Specification Mil-C-4339B. Drain and replace plug.

Brush or spray a film of rust preventive compound U. S. Military Specification Mil-C-16173C, Grade 3 on all exposed, unpainted surfaces of engine.

18. Cover all engine openings, including manifold exhaust and intake ports, coolant inlets to cylinder head and block, oil breather and crankcase, with heavy paper and tape.

19. Tag engine to indicate that it has been treated with preservatives and should not be turned over until ready to run due to possible reduction of the protective film. Tag should show coolant has been removed. The tag should show date of treatment and indicate that engine is not ready to run without prior removal of film.

20. Store engine in a place protected from weather and where air is dry and temperature uniform, if possible.

Note: Engines in storage more than 24 months should, if practical, be thoroughly flushed out with a suitable solvent or light, hot oil and then be reprocessed with rust preventive materials. Periodically inspect engines for rust or corrosion. Take corrective action if necessary.

Preparing A Stored Engine For Service

When an engine is removed from storage and put into service, the operations listed below should be performed. Inspections will be limited to operations indicated for applicable length of storage time.

Clean Engine Thoroughly

1. Clean off all accumulated dirt from exterior of engine.
2. Remove all paper covers, tape and wrappings.
3. Use suitable solvent, cleaner or degreaser to remove rust preventive compound from unpainted surfaces of the engine.
4. Remove plug from oil header and force hot, light mineral oil through the oil passages to flush away all preservative oil and gummed oil that may have accumulated. Bar engine over three or four times during flushing operation.
5. Flush cooling system.

Inspection

The length of time the engine has been in storage determines scope of inspection advisable before starting engine.

1. When an engine has been stored for six months or less, it is necessary to make only a routine initial inspection. This inspection includes adjustment of injectors, valves and fan belts, and checking head studs or capscrews, oil filter and connections, air filter, screens and traps.

2. When an engine has been stored for a period of six months or more, the following inspection procedure should be followed:

a. Flush entire fuel system with clean fuel oil until all preservative oil is removed.

b. Remove all screens and check to make sure they are clean before engine is started.

c. Remove and inspect one main bearing and one cylinder liner. If they are in good condition, it is safe to assume the others are in similar condition. If evidence of corrosion is found, complete disassembly and inspection is necessary. If no corrosion is evident, proceed with inspection as outlined for "engine stored less than six months".

Precautions

When the combustion chambers are treated, remember that total volume of combustion space is small and any excessive preservative oil may cause hydrostatic lock, seriously damaging engine if it is started before all the oil is removed.

When recommissioning a stored engine, care should be taken to see that any foreign matter which may collect on screens and strainers during initial operation is removed before considering the engine properly prepared for future service.

Starting the Engine

After inspecting the engine and parts, make sure all preservative oil and gummed oil has been flushed away. Start engine as described in Section II of Operation and Maintenance.

Flywheel and Housing—Unit 1501

1. In selectina flvwheels, check carefully for safe-speed rating. Flywheels must not be applied over their rated safe speed.

2. No attempt should be made to remachine flywheels in a shop that is not equipped to maintain factory standards both as to dimensions and static balance. The static balance tolerance of flywheels is 2 in. oz. [144.0160 g cm] maximum.

Caution: Never reface flywheel beyond point where clutch face is less than 5/8 in. [15.8750 mm] thick.

3. One of the most important factors of good service from the engine and drive units is proper flywheel and housing alignment. Consult Group 14 for alignment procedures to be followed during engine assembly.

Replacement Of Flywheel Ring Gears

Inspection and Removal

1. Inspect ring gear for broken or cracked teeth.
2. If replacement is necessary, drive gear from flywheel with blunt chisel.

Replacement

1. If an oven with a heat control is not available, heat gear with a heating torch — not a cutting torch — from insid diameter so heat travels outward to teeth.
2. Use a Tempilstick crayon or equivalent to determin amount of heat applied.

a. Stroke gear with 600° F. [315.6° C.] crayon several time while applying heat.

b. The crayon will leave a chalk mark until temperatur reaches 600° F. [315.6° C.]. At 600° F. [315.6° C.], the cray on will leave a liquid smear.

Caution: Overheating to temperatures above 660° [348.9° C.] will soften gear.

3. Place ring gear on flywheel and quickly drive onto flywhe until gear is firmly seated.

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Specifications and Wear Limits

Worn limits as stated in this manual indicates that the part may be reused if it is at the worn limit. Discard only if it exceeds the worn limit. Of course, the reuse of any part is partially the responsibility of the person making the inspection, as it could well be damaged in an area not listed as a worn limit, thus making it unfit for further use.
Limits are given in U.S. and Metric measurements. All Metric units are enclosed in brackets [ ].

Unit No.	Part or Location	C Series New Minimum	New Maximum	Worn Limit
101	**Cylinder Block**			
	Installed Camshaft	1.8745	1.8765	1.8780
	Bushing Inside Diameter	[47.6123]	[47.6631]	[47.7012]
	Camshaft Bushing Bore			
	In Block No. 2-7	2.0035	2.0045	2.0055
		[50.8889]	[50.9143]	[50.9397]
	No. 1 Bore for Thrust Plate	2.1245	2.1255	2.1265
		[53.9623]	[53.9877]	[54.0131]
	Cylinder Liner Counterbore			
	Inside Diameter	5.187	5.189	
		[131.7498]	[131.8006]	
	Oversize Flange Liners	None	None	
	Cylinder Liner Counterbore			
	Depth	0.3092	0.3105	0.4023
		[7.8536]	[7.8867]	[10.2184]
	Cylinder Liner Protrusion	0.004	0.006	
		[0.1016]	[0.1524]	
	Liner-to-Block Clearance —	Liner May Contact Block if it Does Not Force Liner Out of Round		
	Lower Bore			
	Diametrical	0.005	0.009	
	Lower Liner Bore	[0.1270]	[0.2286]	
	Inside Diameter	4.933	4.935	
	Main Bearing Bore	[125.2982]	[125.3490]	
		4.1240	4.1250	4.1255
		[104.7496]	[104.7750]	[104.7877]
	Tappet Bore In Block			
	Injector	1.3120	1.3130	1.3145
		[33.3248]	[33.3502]	[33.3883]
	Valve	1.1870	1.1880	1.1895
		[30.1498]	[30.1752]	[30.2133]
	Idler Gear Shaft	1.4975	1.4985	1.4995
		[38.0365]	[38.0619]	[38.0873]
	Cylinder Block Height			
	From Main Bearing Bore			
	Center Line	15.122	15.124	15.114
		[384.0988]	[384.1496]	[383.8956]
	From Top of Alignment Bar	13.0600	13.0615	13.0500
		[331.7240]	[331.7621]	[331.4700]
	Cylinder Liner Counterbore			
	Shims	0.0063	0.0077	Pt. No. 124107
		[0.1600]	[0.1955]	
		0.0072	0.0088	Pt. No. 124108
		[0.1828]	[0.2235]	
		0.0081	0.0099	Pt. No. 124109
		[0.2057]	[0.2514]	
		0.018	0.022	Pt. No. 124110
		[0.4572]	[0.5588]	

nit lo.	Part Name or Location	C Series New Minimum	New Maximum	Worn Limit
		0.028 [0.7112]	0.034 [0.8636]	Pt. No. 124111
	Main Bearing Cap Fit In Block	— 0.002 [— 0.0508]	— 0.004 [— 0.1016]	0.001 [0.0254]
	Main Bearing Capscrew Tightening			
	1. Tighten to	65 ft. lb. [8.9895 kg m]	75 ft. lb. [10.3725 kg m]	
	2. Advance to	140 ft. lb. [19.3620 kg m]	150 ft. lb. [20.7450 kg m]	
	3. Loosen	All		
	4. Tighten to	45 ft. lb. [6.2235 kg m]	50 ft. lb. [6.9150 kg m]	
	5. Advance	60°		
02	**Cylinder Liner**			
	Cylinder Liner (I.D.) — Cast Iron	4.4370 [112.6998]	4.4380 [112.7252]	4.4420 [112.8268]
	Cylinder Liner Protrusion	0.004 [0.1016]	0.006 [0.1524]	
03	**Idler Gear**			
	Idler Gear Bushing (I.D.)	2.125 [53.9750]	2.126 [54.0004]	2.127 [54.0258]
	Gear Hub Bushing (I.D.)	1.500 [38.1000]	1.501 [38.1254]	1.502 [38.1508]
	Idler Gear Hub	2.1225 [53.9115]	2.1235 [53.9369]	2.1215 [53.8861]
	Idler Thrust Washers — Part Nos.:			
	68631	0.096 [2.4384]	0.106 [2.6924]	0.091 [2.3114]
	68632	0.061 [1.5494]	0.063 [1.6002]	0.059 [1.4986]
	68633-1	0.192 [4.8768]	0.194 [4.9276]	0.190 [4.8260]
04	**Crankshaft**			
	Crankshaft Dimensions	Refer to Table 1-4-1, Page 1-4-3.		
05	**Bearings**			
	Standard Bearing Shell Thickness			
	Main Bearing	0.1231 [3.1267]	0.1236 [3.1394]	0.1216 [3.0886]
	Connecting Rod	0.0722 [1.8338]	0.0727 [1.8465]	0.0710 [1.8034]
	Journal Oil Clearance			
	Main	0.0018 [0.0457]	0.0048 [0.1219]	0.0068 [0.1727]
	Connecting Rod	0.0020 [0.0508]	0.0045 [0.1143]	0.0080 [0.2032]
	Crankshaft Thrust Bearings — Part Nos.:			
	150310	0.151 [3.8354]	0.153 [3.8862]	

Unit No.	Part Name or Location	C Series New Minimum	New Maximum	Worn Limit
	150311	0.161 [4.0894]	0.163 [4.1402]	
	150312	0.171 [4.3434]	0.173 [4.3942]	
	Crankshaft End Clearance	0.004 [0.1016]	0.015 [0.3810]	0.022 [0.5588]
106	**Vibration Dampers**			
	Alignment Mark — Rubber		1/16 [1.5875]	1/16 [1.5875]
	Eccentricity and Wobble		0.030 [0.7620]	0.030 [0.7620]
107	**Counterbalancer**			
	Oil Pan-Enclosed			
	Housing Bushing			
	Shaft Journal			
	Block-Mounted			
	Housing Bushing	2.0015 [50.8381]	2.0045 [50.9143]	2.006 [50.9524]
	Shaft Journal	1.9975 [50.7365]	1.9985 [50.7619]	1.996 [50.6984]
108	**Connecting Rods**			
	Template Tightening "U"-Bolt Nuts:			
	1. Tighten to	15 ft. lb. [2.0745 kg m]	20 ft. lb. [2.7660 kg m]	
	2. Advance to	30 ft. lb. [4.1490 kg m]		
	3. Loosen	All		
	4. Tighten to	15 ft. lb. [2.0745 kg m]	20 ft. lb. [2.7660 kg m]	
	5. Advance to	30 ft. lb. [4.1490 kg m]		
	6. Advance	60°		
	Torque Check	38 ft. lb. [5.2554 kg m]		
	Connecting Rod Dimensions			
	Crankpin Bore	2.7725 [70.4215]	2.7730 [70.4342]	
	Out of Round			0.0015 [0.0381]
	Piston Pin Bushing	1.5000 [38.1000]	1.5005 [38.1127]	1.5015 [38.1381]
	Connecting Rod Twist			
	Without Bushing			0.020 [0.5080]
	With Bushing			0.010 [0.2540]
	Connecting Rod Length	9.498 [241.2492]	9.500 [241.3000]	
	Bore Misalignment			± 0.001 [± 0.0254]
109	**Piston and Piston Rings**			
	Piston Ring Gap (New or reconditioned liner)	0.013 [0.3302]	0.023 [0.5842]	Pt. No. 112880

Part Name or Location	C Series New Minimum	New Maximum	Worn Limit
	0.013 [0.3302]	0.023 [0.5842]	Pt. No. 144970
	0.013 [0.3302]	0.023 [0.5842]	Pt. No. 145150
	0.015 [0.3810]	0.055 [1.3970]	Pt. No. 118630
Standard Piston Skirt Diameter (70° F. [21.1° C.])			
130360, 130500	4.4275 [112.4585]	4.4285 [112.4839]	4.4245 [112.3823]
144840*, 149200	4.4300 [112.5220]	4.4310 [112.5475]	4.4270 [112.4458]
168430	4.4300 [112.5220]	4.4310 [112.5475]	4.4270 [112.4458]
117470			
117110, 117380			
117250, 124860			
117450, 126420			
117440, 126410			
117460, 126430			
130180, 130190			
146300*			
*Three-Ring Piston			
Piston Pin Bore	1.4988 [38.0695]	1.4990 [38.0746]	1.5000 [38.1000]
Piston Pin Diameter	1.4988 [38.0695]	1.4990 [38.0746]	1.4978 [38.0441]
Pistons and Rings Oversize	0.020 [0.5080]	0.030 [0.7620]	0.040 [1.0160]
Camshaft			
Camshaft Journal Diameter			
No. 1 Journal only	1.747 [44.3738]	1.748 [44.3992]	1.746 [44.3484]
All Other Journals	1.872 [47.5488]	1.873 [47.5742]	1.871 [47.5234]
Camshaft Lobe Lift	See Table 1-10-3, Page 1-10-3.		
Gear Cover			
Accessory Drive Bushing I.D.			
139810 Std.	1.314 [33.3756]	1.319 [33.5026]	1.3205 [33.5407]
139811 0.010 in. [0.2540 mm]	1.304 [33.1216]	1.309 [33.2486]	1.3105 [33.2867]
139812 0.020 in. [0.5080 mm]	1.294 [32.8676]	1.299 [32.9946]	1.3005 [33.0327]
Cylinder Head			
Crosshead Guide Dimensions			
Tubular type (I.D.)	0.3755 [9.5377]	0.3760 [9.5504]	0.3780 [9.6012]

Unit No.	Part Name or Location	C Series New Minimum	New Maximum	Worn Limit
	Solid type (O.D.)	0.3750 [9.5250]	0.3755 [9.5377]	0.3740 [9.4996]
	Head Height	5.000 [127.000]	5.010 [127.2540]	4.970 [126.2380]
203	**Valve Seats and Inserts**	Refer to Table 2-3-1, Page 2-3-2.		
	Valve Seat Insert Run-Out		0.002 [0.0508]	
204	**Valve Crossheads**			
	Crosshead Dimensions			
	Solid Stem (O.D.)	0.3708 [9.4183]	0.3713 [9.4310]	0.370 [9.3980]
	Tubular Stem (I.D.)	0.376 [9.5504]	0.378 [9.6012]	0.380 [9.6520]
205	**Valves, Guides and Springs**			
	Valve Stem Dimensions			
	Four-valve Head	0.3400 [8.6360]	0.3410 [8.6614]	0.3390 [8.6106]
	Two-valve Head			
	Valve Guide I.D.			
	Four-valve Head	0.3425 [8.6995]	0.3432 [8.7172]	0.3442 [8.7426]
	Two-valve Head			
	Valve Guide Protrusion			
	Four-valve Head	1.240 [31.4960]	1.260 [32.0040]	
	Two-valve Head			
	Valve Spring Data	Refer to Table 2-5-4, Page 2-5-4.		
301	**Rocker Levers and Cover**			
	Rocker Lever Bushing (I.D.)	1.1245 [28.5623]	1.1275 [28.6385]	1.1285 [28.6639]
	Rocker Lever Shaft (O.D.)	1.1230 [28.5242]	1.1235 [28.5369]	1.1220 [28.4988]
302	**Push Tubes**			
	Valve Push Tube			
	Ball End	0.624 [15.8496]	0.625 [15.8750]	
	Socket End (Spherical I.D.)	0.4995 [12.6873]	0.5005 [12.7127]	
	Injector Push Tube			
	Ball End	0.685 [17.3990]	0.687 [17.4498]	
	Socket End (Spherical I.D.)	0.4995 [12.6873]	0.5005 [12.7127]	

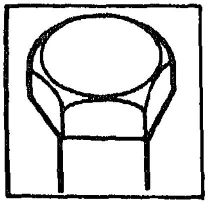
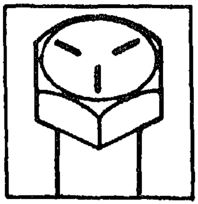
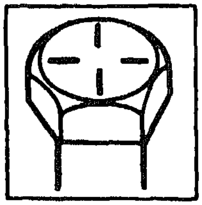
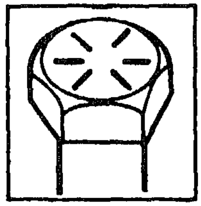
Unit No.	Part Name or Location	C Series New Minimum	New Maximum	Worn Limit
401	**Tappets**			
	Injector Tappet Assembly Body (O.D.)	1.3100 [33.2740]	1.3110 [33.2994]	1.3090 [33.2486]
	Roller (O.D.)	1.1230 [28.5242]	1.1250 [28.5750]	1.1210 [28.4734]
	Roller (I.D.)	0.5655 [14.3637]	0.5665 [14.3891]	0.5675 [14.4145]
	Roller Pin (O.D.)	0.5620 [14.2748]	0.5626 [14.2900]	0.5610 [14.2494]
	Roller Side Clearance	0.0050 [0.1270]	0.0170 [0.4318]	0.0220 [0.5588]
	Roller Concentricity Assembled		0.0005 [0.0127]	
	Roller Squareness Assembled		0.0010 [0.0254]	
	Valve Tappet Assembly Body (O.D.)	1.1850 [30.0990]	1.1860 [30.1244]	1.1840 [30.0763]
	Roller (O.D.)	1.0610 [26.9494]	1.0630 [27.0002]	1.0590 [26.8986]
	Roller (I.D.)	0.5030 [12.7762]	0.5040 [12.8016]	0.5050 [12.8270]
	Roller Pin (O.D.)	0.4995 [12.6873]	0.5000 [12.7000]	0.4985 [12.6619]
	Roller Side Clearance	0.0080 [0.2032]	0.0220 [0.5588]	0.0270 [0.6858]
	Roller Concentricity Assembled		0.0010 [0.0254]	
	Roller Squareness Assembled		0.0010 [0.0254]	
701	**Lubricating Oil Pan**			
	Oil Pan Capacity and Angularity	Reference Table 7-1-1, Page 7-1-3.		
702	**Lubricating Oil Lines**			
	Hose Bends	Refer to Table 7-22, Page 7-2-2.		
706	**Lubricating Oil Pump**			
	Lubricating Oil Pump Dimensions			
	Idler and Drive Shaft Bushing (I.D.)	0.6165 [15.6591]	0.6175 [15.6845]	0.6185 [15.7099]
	Idler and Drive Shaft (O.D.)	0.6150 [15.6210]	0.6155 [15.6337]	0.6140 [15.5956]
	Idler Gear Bushings (I.D.)	0.9925 [25.2095]	0.9935 [25.2349]	0.9945 [25.2603]
	Idler Gear Shaft (O.D.)	0.9900 [25.1460]	0.9910 [25.1714]	0.9890 [25.1206]
	Idler and Driven Gear (O.D.)	1.8320 [46.5328]	1.8330 [46.5582]	1.8310 [46.5074]
	Gear Pockets (Minor I.D.)	1.8400 [46.7360]	1.8420 [46.7868]	1.8430 [46.8122]

Unit No.	Part Name or Location	C Series New Minimum	New Maximum	Worn Limit
	Gear Pocket Depth	1.6230 [41.2242]	1.6250 [41.2750]	1.8430 [46.8122]
	Counterbalancer (Oil Pan-Enclosed)			
	Balancer Drive Shaft	0.8095 [20.5613]	0.8105 [20.5867]	
	Balancer Drive Shaft Bushing	0.8145 [20.6883]	0.8150 [20.7010]	0.8170 [20.7518]
	Idler Gear Thrust Washer	0.0610 [1.5494]	0.0630 [1.6002]	
	Balancer Drive Gear Thrust Washer	0.0600 [1.5240]	0.0620 [1.5748]	
	Lube Pump Drive Shaft Bushing	0.6165 [15.6591]	0.6175 [15.6845]	0.6185 [15.7099]
	Double Lubricating Oil Pump Dimensions			
	Idler and Drive Shaft Bushings	0.6165 [15.6591]	0.6175 [15.6845]	0.6185 [15.7099]
	Idler Gear Bushing	0.9925 [25.2095]	0.9935 [25.2349]	0.9945 [25.2603]
	Idler and Drive Shaft (O.D.)	0.6150 [15.6210]	0.6155 [15.6337]	0.6140 [15.5956]
	Idler Gear Spindle Shaft	0.9900 [25.1460]	0.9910 [25.1714]	0.9890 [25.1206]
	Gears (O.D.)	1.8320 [46.5328]	1.8330 [46.5582]	1.8310 [46.5074]
	Body Gear Pockets (Minor I.D.)	1.8400 [46.7360]	1.8420 [46.7868]	1.8430 [46.8122]
707	**Pressure Regulator**			
	Pressure Regulator Dimensions			
	Low Pressure (I.D.)	0.621 [15.7734]	0.626 [15.9004]	0.627 [15.9258]
	Low Pressure (O.D.)	0.740 [18.7960]	0.741 [18.8214]	0.739 [18.7706]
	High Pressure (Large Outside)	0.740 [18.7960]	0.741 [18.8214]	0.739 [18.7706]
	High Pressure (Small Outside)	0.615 [15.6210]	0.617 [15.6718]	0.614 [15.5956]
	Housing Bore	0.740 [18.7960]	0.741 [18.8214]	0.739 [18.7706]
	Spring Load @ 2.055 in. [52.1970 mm]	16.4 lb. [7.4390 kg]	18.01 lb. [8.1693 kg]	14.0 lb. [6.3504 kg]
	Lube Oil By-Pass Valve Spring Data			
	66507-1	Free Length — 2.185/2.371 in. [55.4990/60.2234 mm] Load — 40 ± 4.5 lb. [18.1440 ± 2.0412 kg] @ Length — 7/8 in. [22.2250 mm]		
	251152	Free Length — 1.520/1.680 in. [38.6080/42.6720 mm] Load — 11.2 ± 1.1 lb. [5.0803 ± 0.4990 kg] @ Length — 0.80 in. [20.3200 mm]		

Part Name or Location	C Series New Minimum	New Maximum	Worn Limit
Water Pump			
Supercharger-Driven			
Cover Face to Impeller Hub	0.872 [22.1488]	0.878 [22.3012]	
Thermostats			
Thermostat Operating Range			
Low Range	160° F. [71.1° C.]	175° F. [79.4° C.]	
Medium Range	175° F. [79.4° C.]	185° F. [85.0° C.]	
High Range	180° F. [82.2° C.]	195° F. [90.6° C.]	
Fuel Pump Drive			
Fuel Pump and Compressor Drive			
Bushing (I.D.)	1.314 [33.3756]	1.319 [33.5026]	1.322 [33.5788]
Available for Service in	0.010 [0.2540] and 0.020 [0.5080] undersize		
Shaft (O.D.)	1.3115 [33.3111]	1.312 [33.3248]	1.310 [33.2740]
Supercharger			
Supercharger Assembly Dimensions			
Radial Bearing Clearance			0.003 [0.0762]
Gear Backlash			0.004 [0.1016]
Rotor Shaft End Play	0.003 [0.0762]	0.004 [0.1016]	0.005 [0.1270]
Gear Hub Protrusion	0.002 [0.0508]	0.005 [0.1270]	0.005 [0.1270]
Rotor to Rotor Clearance	0.006 [0.1524]		
Rotor to Housing Clearance	0.005 [0.1270]		
Rotor to Gear Plate	0.003 [0.0762]	0.004 [0.1016]	
Rotor Shaft Bushing			1.3765 [34.9631]

Unit No.	Part Name or Location	C Series New Minimum	New Maximum	Worn Limit
1102	**Mufflers and Piping**			
	Exhaust Back Pressure (Inches of Mercury)			
	Naturally Aspirated and Supercharged Engines		1.5 [38.1000]	
	Turbocharged Engines		2.0 [50.8000]	
1301	**Cranking Motors**			
	Cable Sizes	Refer to Table 13-1-1, Page 13-1-3.		
	Battery Capacity	Refer to Table 13-1-2, Page 13-1-8.		
	Ampere-Hour Capacity	Refer to Table 13-1-3, Page 13-1-8.		
	Voltage Drop	Refer to Table 13-1-4, Page 13-1-10.		
	Voltage Drop Feet	Refer to Table 13-1-5, Page 13-1-10.		
1401	**Engine Assembly**			
	Main Bearing Capscrew Torque	Refer to Page 14-1-2.		
	Crankshaft End Clearance	0.004 [0.1016]	0.015 [0.3810]	0.022 [0.5588]
	Cylinder Liner Protrusion	0.004 [0.1016]	0.006 [0.1524]	
	Liner Counterbore Shims	Refer to Table 14-1-1, Page 14-1-5.		
	Connecting Rod Side Clearance	0.008 [0.2032]	0.012 [0.3048]	0.040 [1.0160]
	Gear Train Backlash (Six-Cylinder)	0.004 [0.1016]	0.007 [0.1778]	0.020 [0.5080]
	Camshaft End Play	0.007 [0.1778]	0.011 [0.2794]	0.015 [0.3810]
	Injector Timing Procedure	Refer to Page 14-1-14.		
	Injector Adjustment	Refer to Page 14-1-31		
	Flywheel Specifications	Refer to Groups 14 and 15		
	Flywheel Housing Specifications	Refer to Group 14		
	Engine Firing Order	Refer to Page 14-1-33		
1402	**Engine Testing**			
	Dynamometer Test	Refer to Page 14-2-5		

Standard Capscrew Markings and Torque Specifications

urrent Usage	Much Used	Much Used	Used at Times	Used at Times
linimum Tensile Strength psi	To 1/2 — 69,000 To 3/4 — 64,000 To 1 — 55,000	To 3/4 — 120,000 To 1 — 115,000	To 5/8 — 140,000 To 3/4 — 133,000	150,000
uality of Material	Indeterminate	Minimum Commercial	Medium Commercial	Best Commercial
AE Grade Number	1 or 2	5	6	8
olt Head Markings lanufacturer's marks may vary. hese are all SAE Grade 5 (3-line).				

olt Body Size (nches) — (Thread)	Torque Ft-Lb	[kg m]	Torque Ft-Lb	[kg m]	Torque Ft-Lb	[kg m]	Torque Ft-Lb	[kg m]
1/4 — 20	5	[0.6915]	8	[1.1064]	10	[1.3830]	12	[1.6596]
— 28	6	[0.8298]	10	[1.3830]			14	[1.9362]
/16 — 18	11	[1.5213]	17	[2.3511]	19	[2.6277]	24	[3.3192]
— 24	13	[1.7979]	19	[2.6277]			27	[3.7341]
3/8 — 16	18	[2.4894]	31	[4.2873]	34	[4.7022]	44	[6.0852]
— 24	20	[2.7660]	35	[4.8405]			49	[6.7767]
/16 — 14	28	[3.8132]	49	[6.7767]	55	[7.6065]	70	[9.6810]
— 20	30	[4.1490]	55	[7.6065]			78	[10.7874]
1/2 — 13	39	[5.3937]	75	[10.3725]	85	[11.7555]	105	[14.5215]
— 20	41	[5.6703]	85	[11.7555]			120	[16.5960]
/16 — 12	51	[7.0533]	110	[15.2130]	120	[16.5960]	155	[21.4365]
— 18	55	[7.6065]	120	[16.5960]			170	[23.5110]
5/8 — 11	83	[11.4789]	150	[20.7450]	167	[23.0961]	210	[29.0430]
— 18	95	[13.1385]	170	[23.5110]			240	[33.1920]
3/4 — 10	105	[14.5215]	270	[37.3410]	280	[38.7240]	375	[51.8625]
— 16	115	[15.9045]	295	[40.7985]			420	[58.0860]
7/8 — 9	160	[22.1280]	395	[54.6285]	440	[60.8520]	605	[83.6715]
— 14	175	[24.2025]	435	[60.1605]			675	[93.3525]
1 — 8	235	[32.5005]	590	[81.5970]	660	[91.2780]	910	[125.8530]
— 14	250	[34.5750]	660	[91.2780]			990	[136.9170]

. Always use the torque values listed above when specific specifications are not available.

Note: Do not use these values in place of those specified in the above engine groups.

. The above is based on use of clean and dry threads.

. Reduce torque by 10% when engine oil is used as a lubricant.

. Reduce torque by 20% if new plated bolts are used.

Caution: Bolts threaded into aluminum may require reductions in torque of 30% or more, unless inserts are used.

Torque Specifications

BASIC ISSUE ITEMS LIST

Section I. INTRODUCTION

1. Scope

This appendix lists items which accompany the fork lift truck or are required for installation, operation, or operator's maintenance.

2. General

This Basic Issue Items List is divided into the following sections:

a. Basic Issue Items -- Section II. This section is a listing of accessories, repair parts, tools, and publications required for operator's maintenance and operation, initially issued with, or authorized for the fork lift truck.

b. Maintenance and Operating Supplies -- Section III. This section is a listing of maintenance and operating supplies required for initial operation.

3. Explanation of Columns

The following provides an explanation of columns in the tabular list of Basic Issue Items, Section II:

a. Source, Maintenance, and Recoverability Codes (SMR), Column 1:

(1) Source Code indicates the selection status and source for the listed item. Source codes are:

from GSA/DSA Army supply system, and authorized for use at indicated maintenance categories.

(2) Maintenance Code indicates the lowest category of maintenance authorized to install the listed item. The maintenance level code is:

de	Explanation
	Operator/Crew

(3) Recoverability Code indicates whether unserviceable items should be returned for recovery or salvage. Items not coded are expendable.

b. Federal Stock Number, Column 2. This column indicates the deral Stock Number for the item.

c. Description, Column 3. This column indicates the Federal em name and any additional description required. A five-digit nufacturer's or other service code is shown in parentheses followed the manufacturer's part number. Repair parts quantities included kits, sets, and assemblies that differ from the actual quantity ed in the specific item, are listed in parentheses following the pair part name.

d. Unit of Issue, Column 4. This column indicates the unit used a basis of issue, e.g., ea, pr, ft, yd, etc.

e. Quantity Incorporated in Unit Pack, Column 5. This column dicates the actual quantity contained in the unit pack.

f. Quantity Incorporated in Unit, Column 6. This column indicates the quantity of the item used in the equipment.

g. Quantity Furnished With Equipment, Column 7. This column indicates the quantity of an item furnished with the equipment in excess of the quantity incorporated in the unite.

h. Quantity Authorized, Column 8. This column indicates the quantity of an item authorized the operator/crew to have on hand or to obtain as required. As required items are indicated with an asterisk.

i, Illustration, Column 9. This column is divided as follows:

(1) Figure Number, column 9a, indicates the figure number of the illustration in which the item is shown.

(2) Item Number, Column 9b, indicates the callout number used to reference the item in the illustration.

4. Explanation of Columns in the Tabular List of Maintenance and Operating Supplies -- Section III

a. Item, Column 1. This column contains numerical sequence ite numbers assigned to each component application to facilitate referen

b. Component Application, Column 2. This column identifies the component application of each maintenance or operating supply item.

c. Federal Stock Number, Column 3. This column indicates the Federal Stock Number for the item and will be used for requisitionin purposes.

d. Description, Column 4. This column indicates the item and a brief description.

olumn indicates the quantity of each maintenance or operating upply item required for initial operation of the equipment.

f. Quantity Required for 8 Hours Operation, Column 6. This olumn indicates the estimated quantities required for an average ght hours of operation.

g. Notes, Column 7. This column indicates informative notes yed to data appearing in a preceding column.

SECTION II 5/5 e1

BASIC ISSUE ITEMS LIST

(1) [SOU]RCE, MAINT, AND RECOV CODE (A)	(1) (B) M	(1) (C) R	(2) FEDERAL STOCK NO.	(3) DESCRIPTION	(4) UNIT OF ISSUE	(5) QTY INC IN UNIT PACK	(6) QTY INC IN UNIT	(7) QTY FURN WITH EQUIP	(8) QTY AUTH	(9) ILLUSTRATION (A) FIG NO.	(9) (B) ITEM NO.
	.			3100 - BASIC ISSUE ITEMS Manufacturer or Depot Installed							
	C		7510-889-3494	BINDER, LOOSE LEAF: US ARMY EQUIPMENT LOG	EA			1	1		
	C		7510-244-0359	CONTAINER, PLASTIC; LOGBOOK BINDER	EA			1	1		
	C		7520-559-9618	CASE, OPERATION AND MAINTENANCE MANUALS	EA			1	1		
	C		4210-889-2221	EXTINGUISHER, FIRE: DRY, HAND TYPE, $2\frac{1}{2}$ LB. FED SPEC. O-E-95, TYPE III, CLASS 2	EA			1	1		
				ARMY TECHNICAL MANUAL TM 5-3805-243-15	EA			1	1		
				ARMY LUBRICATION ORDER LO 5-3805-243-12	EA			1	1		
				3200 - BASIC ISSUE ITEMS Troop Installed or Authorized							
	C		4910-922-6921	KIT, REPAIR: TUBELESS TIRE	EA			1	1		

(2) COMPONENT APPLICATION	(3) FEDERAL STOCK NUMBER	(4) DESCRIPTION	(5) QUANTITY REQUIRED F/INITIAL OPERATION	(6) QUANTITY REQUIRED F/8 HRS OPERATION	(7) NOTES
CRANKCASE	9150-265-9435	LUBRICATING OIL, Engine; MIL-L-2104, OE-30, 5 gal pail	19 qt.		Crankcase cap. 4 US Gal.
FUEL TANK	9140-286-5283	FUEL OIL, Diesel, Fed Spec VV-F-800, Grade DF-2, bulk	83 gal.		Tank capacity 83 US Gal. Normal fuel consumption 4.5 gal per hour
GENERAL APPLI-CATION	9150-190-0905	GREASE, Automotive and Artillery; MIL-G-10924, 5 pound can	AR		
RADIATOR	6850-243-1990	ANTIFREEZE, Ethylene-Glycol; 55 Gal drum	AR		System capacity 48 US qts. See TB ORD 651, 10 Apr.64.
BRAKE SYSTEM	9150-252-6375	BRAKE FLUID, Automotive, MIL-H-13910, 1 gal can	2 pt.		
HYDRAULIC TANK	9150-265-9430	LUBRICATING OIL, Engine; MIL-L-2104, OE-10, 55 gal drum	56 gal.		Main and steering system cap. 50 US Gal, Transmission system cap. 6 us gal.
PLANETARY DRIVES	9150-577-5844	LUBRICATING OIL, Gear, MIL-L-2105, GO-90, 5 gal pail	59 qts		Differential caps. 12 US gals. Hubs cap. 11 US qt.

1. General

a. This section provides a general explanation of all maintenance and repair functions authorized at various maintenance levels.

b. Section II designates overall responsibility for the performance of maintenance functions on the identified end item or component. The implementation of the maintenance functions upon the end item or component will be consistent with the assigned maintenance functions.

c. Section III lists the special tools and test equipment required for each maintenance function as referenced from Section II.

d. Section IV contains supplemental instructions, explanatory notes and/or illustrations required for a particular maintenance function.

2. Explanation of Columns in Section II

a. Group Number. Column 1. The functional group is a numerical group set up on a functional basis. The applicable functional grouping indexes (obtained from TB 750-93-1, Functional Grouping Codes) are listed on the MAC in the appropriate numerical sequence. These indexes are normally set up in accordance with their function and proximity to each other.

b. Functional Group. Column 2. This column contains a brief description of the components of each functional group.

ntenance functions (A through K) and indicates the lowest maintenance egory authorized to perform these functions. The symbol designations the various maintenance categories are as follows:

C - Operator or crew

O - Organizational maintenance

F - Direct support maintenance

H - General support maintenance

D - Depot maintenance

maintenance functions are defined as follows:

INSPECT. To determine serviceability of an item by comparing its physical, mechanical, and electrical characteristics with established standards.

TEST. To verify serviceability and to detect electrical or mechanical failure by use of test equipment.

SERVICE. To clean, to preserve, to charge, to paint, and to add fuel, lubricants, cooling agents, and air.

ADJUST. To rectify to the extent necessary to bring into proper operating range.

ALIGN. To adjust specified variable elements of an item to bring to optimum performance.

CALIBRATE. To determine the corrections to be made in the readings of instruments or test equipment used in precise measurement. Consists of the comparisons of two instruments, one of which is a certified standard of known accuracy, to detect and adjust any discrepancy in the accuracy of the instrument being compared with the certified standard.

H - REPLACE. To replace unserviceable items with serviceable assemblies, subassemblies, or parts.

I - REPAIR. To restore an item to serviceable condition. This includes, but is not limited to, inspection, cleaning, preserving, adjusting, replacing, welding, riveting, and strengthening.

J - OVERHAUL. To restore an item to a completely serviceable condition a prescribed by maintenance serviceability standards using the Inspect and Repair Only as Necessary (IROAN) technique.

K - REBUILD. To restore an item to a standard as nearly as possible to original or new condition in appearance, performance, and life expectancy. This is accomplished through complete disassembly of the item, inspection of all parts or components, repair or replacement of worn or unserviceable elements (items) using original manufacturin tolerances and specifications, and subsequent reassembly of the item.

d. Tools and Equipment. Column 4. This column is provided for referencing by code the special tools and test equipment, (Section III) required to perform the maintenance functions (Section II).

e. Remarks. Column 5. This column is provided for referencing by co the remarks (Section IV) pertinent to the maintenance functions.

3. Explanation of Columns in Section III

a. Reference Code. This column consists of a number and a letter separated by a dash. The number references the T&TE requirements column on the MAC. The letter represents the specific maintenance function the item is to be used with. The letter is representative of columns A throu

tenance authorized to use the special tool or test equipment.

c. Nomenclature. This column lists the name or identification of tool or test equipment.

d. Tool Number. This column lists the manufacturer's code and part er, or Federal Stock Number of tools and test equipment.

Explanation of Columns in Section IV

a. Reference Code. This column consists of two letters separated dash, both of which are references to Section II. The first letter rences column 5 and the second letter references a maintenance function, mn 3, A through K.

b. Remarks. This column lists information pertinent to the maintenance tion being performed, as indicated on the MAC, Section II.

SECTION II - MAINTENANCE ALLOCATION CHART

(1) GROUP NO.	(2) FUNCTIONAL GROUP	(3) MAINTENANCE FUNCTIONS A INSPECT	B TEST	C SERVICE	D ADJUST	E ALIGN	F CALIBRATE	G INSTALL	H REPLACE	I REPAIR	J OVERHAUL	K REBUILD	(4) TOOLS AND EQUIPMENT	(5) REMAR
01	ENGINE													
0100	Engine Assembly	O	F	C					F	F	H	D		A
0101	Block Cylinder Head:													
	Block								D	D		D		
	Cylinder Head								F	H		D		
0102	Crankshaft	H							H			D		B
0103	Flywheel Assembly:													
	Flywheel Assembly								H	H				
	Housing	O							H	H				
0105	Valves, Camshafts and Timing Systems:													
	Arm, Rocker				F				F	F				
	Cover, Cylinder Head								O	F				
	Valves, Lifters	F							F					
	Seat Inserts	F							H	F				C
0106	Engine Lubricating System:													
	Breather			O					O					
	Filter, Oil			O					O					

(1)	(2)	(3) MAINTENANCE FUNCTIONS											(4)	(5)
		A	B	C	D	E	F	G	H	I	J	K		
GROUP NO.	FUNCTIONAL GROUP	INSPECT	TEST	SERVICE	ADJUST	ALIGN	CALIBRATE	INSTALL	REPLACE	REPAIR	OVERHAUL	REBUILD	TOOLS AND EQUIPMENT	REMARKS
0106	Engine Lubricating System (continued):													
	Pan, Oil								H	H				
	Pump, Oil								H	H				
0108	Manifolds	O							F					
0109	Accessory Drive Mechanism:													
	Accessory Drive								H	H				
03	FUEL SYSTEM													
0301	Fuel Injector:													
	Injector, Fuel		F		F				F	F		D	1	
	Injector Inlet Screen			O					O					
0302	Fuel Pumps:													
	Pump, Fuel				F				F			D		
	Pump Inlet Screen			O					O					
0304	Air Cleaner			O					O	O				
0305	Supercharger:													
	Supercharger								F			D		

SECTION II - MAINTENANCE ALLOCATION CHART

(1) GROUP NO.	(2) FUNCTIONAL GROUP	(3) MAINTENANCE FUNCTIONS A INSPECT	B TEST	C SERVICE	D ADJUST	E ALIGN	F CALIBRATE	G INSTALL	H REPLACE	I REPAIR	J OVERHAUL	K REBUILD	(4) TOOLS AND EQUIPMENT	(5) REMARKS
0305	Supercharger (continued): Hose and Clamps	O							O					
0306	Tanks, Lines, Fittings	O		C					F	F				
0309	Fuel Filters			O					O					
0311	Engine Starting Aids			O					O					
0312	Accelerator, Throttle Controls				O				O					
05	COOLING SYSTEM													
0501	Radiator:													
	Radiator	C		C					O	H				
	Grille								O	F				
0503	Thermostat and Housing Gaskets:													
	Thermostats		O						O					

(1) GROUP NO.	(2) FUNCTIONAL GROUP	(3) MAINTENANCE FUNCTIONS A INSPECT	B TEST	C SERVICE	D ADJUST	E ALIGN	F CALIBRATE	G INSTALL	H REPLACE	I REPAIR	J OVERHAUL	K REBUILD	(4) TOOLS AND EQUIPMENT	(5) REMARKS
0505	Fan Assembly:													
	Belt	C			O				O					
	Hub Assembly			O					F	F				
0508	Water Filter:													
	Corrosion Resistor			O					O					
	Filter			O					O					
06	ELECTRICAL SYSTEM													
0601	Generator:													
	Belt	C			O				O					
	Generator		O						O	F		H		
0602	Generator, Regulator		O		F				O					
0603	Starting Motor:													
	Brushes, Solenoid								F	F				
	Motor, Starting		O						O	F		H		
0612	Batteries	C	O	C					O					
0613	Chassis Wiring Harness								F	O				

SECTION II - MAINTENANCE ALLOCATION CHART

(1) GROUP NO.	(2) FUNCTIONAL GROUP	(3) MAINTENANCE FUNCTIONS A INSPECT	B TEST	C SERVICE	D ADJUST	E ALIGN	F CALIBRATE	G INSTALL	H REPLACE	I REPAIR	J OVERHAUL	K REBUILD	(4) TOOLS AND EQUIPMENT	(5) REMARKS
07	TRANSMISSION													
0705	Gear Shift and Controls: Levers and Linkage				O				O					
0708	Torque Converter								F			D		
0710	Transmission Assembly: Transmission Assembly		F	O					H			D		
	Breather			O					O					
0721	Coolers, Pumps: Filter Element			O					O					
09	PROPELLER SHAFTS			O					O					
10	FRONT AXLE													
1000	Front Axle Assembly: Axle Assembly, Front	O		O					F	H		D		
	Breather			O					O					
1002	Differential Assembly			O					F	H		D		

(1) GROUP NO.	(2) FUNCTIONAL GROUP	(3) MAINTENANCE FUNCTIONS A INSPECT	B TEST	C SERVICE	D ADJUST	E ALIGN	F CALIBRATE	G INSTALL	H REPLACE	I REPAIR	J OVERHAUL	K REBUILD	(4) TOOLS AND EQUIPMENT	(5) REMARKS
1003	Planetary Drive			O					F	F	H			
11	REAR AXLE													
1100	Rear Axle Assembly:													
	Axle Assembly, Rear	O		O					F	H		D		
	Breather			O					O					
1102	Differential Assembly			O					F	H		D		
1103	Planetary Drive			O					F	F	H			
12	BRAKES													
1201	Hand Brakes:													
	Brake, Hand			O	O				O	F				
	Levers, Linkage			O	O				O					
1202	Service Brakes				O				F	F				
1204	Hydraulic Brake System:													
	Power Cluster			O					F		H			
	Cylinder Wheel								F		H			

(1) GROUP NO.	(2) FUNCTIONAL GROUP	(3) MAINTENANCE FUNCTIONS A INSPECT	B TEST	C SERVICE	D ADJUST	E ALIGN	F CALIBRATE	G INSTALL	H REPLACE	I REPAIR	J OVERHAUL	K REBUILD	(4) TOOLS AND EQUIPMENT	(5) REMARKS
1208	Air Brake System:													
	Chamber, Valves								F		H			
	Reservoir, Air			O					O					
1209	Air Compressor Assembly:													
	Compressor Assembly								F	F	H			
	Governor				O				O					
13	WHEELS													
1311	Wheel Assembly:													
	Drums								F	F				
1313	Tires	O		O					O	O		D		
14	STEERING													
1401	Stering Assembly:													
	Link, Drag, Rod, Tie			O					O					
	Steering Assembly	O		O	F				F	F				
1410	Hydraulic Pump Assembly:													
	Pump, Steering								O		H			

(1) GROUP NO.	(2) FUNCTIONAL GROUP	(3) MAINTENANCE FUNCTIONS A INSPECT	B TEST	C SERVICE	D ADJUST	E ALIGN	F CALIBRATE	G INSTALL	H REPLACE	I REPAIR	J OVERHAUL	K REBUILD	(4) TOOLS AND EQUIPMENT	(5) REMARKS
1412	Hydraulic Cylinders:													
	Cylinder, Steering								O	H				
	Filter, Steering			O					O					
1414	Steering System Valves								F	H				
15	FRAME													
1501	Frame Assembly:													
	Pins and Bushing, Pivot				F				F					
18	BODY, HOOD													
1801	Body, Hood Assemblies:													
	Hood, Panels, Shroud								O	F				
1805	Floors								O	F				
1806	Seats								O	F				
1808	Boxes:													
	Box Tool								O	F				
43	HYDRAULIC SYSTEM													

SECTION II - MAINTENANCE ALLOCATION CHART

(1) GROUP NO.	(2) FUNCTIONAL GROUP	(3) MAINTENANCE FUNCTIONS A INSPECT	B TEST	C SERVICE	D ADJUST	E ALIGN	F CALIBRATE	G INSTALL	H REPLACE	I REPAIR	J OVERHAUL	K REBUILD	(4) TOOLS AND EQUIPMENT	(5) REMARKS
4301	Strainers, Filters, Hoses, Pipe Fittings, Tubing	O		O					O					
4302	Pump								F	H				
4305	Manifold and/or Control Valves								F	H				
4307	Hydraulic Cylinders								O		H			
4308	Reservoirs:													
	Breather			O					O					
	Reservoir			O					F	F				
4309	Manual Controls: Levers, Linkage				O				O					
50	PNEUMATIC EQUIPMENT													
5001	Crankcase, Block Cylinder Head:													
	Crankcase or Block								H	H				
	Cylinder Head								F	H				

(1) GROUP NO.	(2) FUNCTIONAL GROUP	(3) MAINTENANCE FUNCTIONS A INSPECT	B TEST	C SERVICE	D ADJUST	E ALIGN	F CALIBRATE	G INSTALL	H REPLACE	I REPAIR	J OVERHAUL	K REBUILD	(4) TOOLS AND EQUIPMENT	(5) REMARKS
5004	Piston, Connecting Rods								H	H				
5007	Compressor Drives								F	F				
74	EARTH MOVING EQUIPMENT COMPONENTS													
7436	Lift Arms and Pivot Assemblies: Bar, Boom, Carrier			O					F	F				
7437	Loader Fork Lift Assemblies: Shafts, Pins, Latches, Forks			O	O				O	O				
76	FIRE FIGHTING EQUIPMENT COMPONENTS													
7603	Fire Extinguisher	O		O					O					

REFERENCE CODE	MAINTENANCE LEVEL	NOMENCLATURE	TOOL NUMBER
1-D	0	Wrench, Torque, 3/8" sq Drive 150 in. lb. Cap.	5120-230-6380
1-D	0	Screwdriver, 3/8" sq Drive	

REFERENCE CODE	REMARKS
A-B	Test includes operation and Compression.
B-K	Repair of Crankshaft includes Metalizing, Aligning and Grinding.
C-I	Repair of Seat inserts includes refacing.

INDEX, PART 2

INDEX, PART 3

By Order of the Secretaries of the Army and the Navy:

W.C. WESTMORELAND,
General, United States Army,
Chief of Staff.

fficial:

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